

EVALUATING A SOUTH AFRICAN MOBILE APPLICATION FOR HEALTHCARE PROFESSIONALS TO IMPROVE DIAGNOSIS AND NOTIFICATION OF PESTICIDE POISONINGS

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Declaration

I, Siti Kabanda (KBNSIT001), hereby declare that the work on which this dissertation/thesis is based in my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Date: 7 March 2017

Abstract

Acute pesticide poisoning (APP) is a major global public health problem, particularly in low -and middle-income countries (LMICs) including South Africa. However, healthcare professionals (HCPs) worldwide have limited training in handling environmental health risks such as from pesticide exposures. Most HCPs lack basic training on APP and, this presents a challenge to HCPs when diagnosing and notifying pesticide-related poisonings. With a recent increase in mobile application technology, this gives a convenient platform to provide training support for HCPs in their clinical practice. An example is the integration of a South African pesticide notification guideline into an existing Emergency Medicine (EM) mobile application. This pesticide notification guideline (PNG) within the EM mobile application aims to provide an immediate point-of-care tool to help HCPs in diagnosis and notify pesticide poisoning cases. Despite this useful platform for training HCPs, there are limited studies that have evaluated mobile applications or technologies to promote HCPs training in LMICs. This study, therefore, aimed to evaluate the Centre for Environmental and Occupational Health Research (CEOHR)'s PGN adapted for the EM mobile application as a tool for improving HCP's ability to diagnose and report APPs.

The protocol (Part A) provides information and a justification for the research study and, describes the methods used to gather and analyse the data. The extended literature review (Part B) provides an overview of studies assessing HCPs' knowledge of and training in pesticide poisonings and the role mobile health technologies play in improving HCPs' knowledge and training in clinical practice. Furthermore, the literature review illustrates the relevant theoretical frameworks and concepts that helps to understand HCPs' behaviour changes when using clinical guidelines or algorithms.

The journal manuscript article (Part C) provides this study's research findings and how it could contribute to the body of knowledge. A total of 50 emergency medicine physicians and registrars participated in the

study. The study found that the majority of the participants (73%) knew pesticide poisoning was a notifiable medical condition in South Africa, however almost half (49%) had never reported a case to the National Department of Health as is required by law. Medical mobile applications were demonstrated to be useful among HCPs study participants for clinical/training support and, most intend to continue using them in the future. Thirty-three percent of the participants were aware of the PNG within the EM application despite only seven participants having actually used it. These seven participants found the guideline contributed in identification of numerous unlabelled pesticides products such as carbamates, and created an awareness of notifying APP cases. In addition, they found the PNG facilitated them in prompt diagnosis and treatment of APP cases. The participants also provided suggestions on how the PNG within EM application could be improved. These included integrating an inbuilt link to notify APP cases to the Department of Health (DOH), adding more images on pesticides, particularly unlabelled, integrating a reminder of how to use the PNG and its regular updates and, adding antidotes with dosages for poisoning cases.

Overall, mobile health technology could be a promising tool to support HCPs' practice activities. However, there is a need to create PNG awareness (i.e. in healthcare systems, medical schools and conferences) among HCPs to promote improved notification of pesticide poisonings to support better policy making and pesticide exposure reduction, particularly in LMICs.

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Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
APP	Acute Pesticide Poisoning
CEOHR	Centre for Environmental and Occupational Health Research
DOH	Department of Health
EM	Emergency Medicine
GPs	General practitioners
HCP	Healthcare professional
HIV	Human Immunodeficiency Virus
ICT	Information and communication technology
LMICs	Low-and middle-income countries
Mg	milligram
mHealth	Mobile Health
OP	Organophosphate
PCC	Poison Control Centre
PIC	Poison Information Centre

PNG	Pesticide Notification Guideline
PPE	Personal Protective Equipment
SA	South Africa
SCT	Social Cognitive Theory
SDGs	Sustainable Development Goals
TOMPSA	The Open Medicine Project South Africa
TB	Tuberculosis
TPB	Theory of Planned Behaviour
UK	United Kingdom
URTI	Upper Respiratory Tract Infection
US	United States
WHO	World Health Organization

PART A: Protocol

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1. Introduction

1.1. Background to the study

Acute pesticide poisoning (APP) is a major global public health problem, with an estimated three million cases occurring every year worldwide leading to approximately 300,000 deaths [1]. Most APPs occur in low-and middle-income countries (LMICs) such as South Africa (SA), mainly in areas where there are low education levels and poor frameworks for pesticide regulation [2], which could be associated with the inappropriate management of pesticides. LMICs lack effective surveillance systems for pesticide poisoning, resulting in limited surveillance data needed for problem solving and policy making [3]. The surveillance process, which begins with reporting and ends with policy decisions, is essential to inform intervention programs or for eradicating pesticides to reduce the incidence and effects of pesticide poisonings.

APP is one of the 33 notifiable medical conditions in SA and HCPs play a critical role in surveillance as they are to notify on all incidents that occur [4]. However, pesticide poisoning is widely under-reported in SA. This could be due to HCPs often misdiagnosing pesticide poisonings, confusing these with other medical conditions and only reporting organophosphate (OP) poisonings. As a result national statistics are distorted, leading to misguided decision-making. Thus it is essential for HCPs to ensure accurate diagnosis and be aware that pesticide poisonings from all pesticide classes must be notified. It has been found that many HCPs globally have limited training and/or skills to handle pesticide poisoning cases [5, 6]. Although there are online manuals and resources available to HCPs, addressing health risks of pesticide exposure, it has been indicated that there is little information available which is easily accessible for busy professionals to improve notification of pesticide

poisoning cases [7]. Due to this, an algorithm/point chart (the pesticide notification guideline) aimed to assist HCPs in diagnosis and reporting was developed by Associate Professor Rother and other stakeholders (including academic researchers, NGO and the SA government) at the University of Cape Town's Centre for Environmental and Occupational Health Research (CEOHR) (see Figure 1) [7].

Examples of Pesticide Active Ingredients Responsible for Poisonings

For accurate treatment and reporting of pesticide poisonings, it is important to find out the active ingredient of the pesticide—found on the label. If there is no label, use the point chart for potential active ingredients.

Organophosphates: Methyl Parathion Ethyl Parathion Malathion Diazinon Fenthion Dichlorvos Chlorpyrifos Trichlorfon	Carbamates: Aldicarb Carbofuran Oxamyl Methomyl Formetanate Methiocarb Aminocarb Mecarbam Bendiocarb Propoxur
Anticoagulants: Brodifacoum Difethialone Chlorofacinone Coumaphor Difencoum Diphacinone Warfarin	Herbicides: Glysophate Atrazine Nicosulfuran Fenoxaprop Alachlor Pendimethalin Halosulfuran-Methyl Paraquat Triclopyr Clopyralid Picloram
Pyrethroids: Allethrin Bifenthrin Cypermethrin Permethrin Deltamethrin	Organochlorines: Lindane (lice shampoo)

N,N-Diethyl-meta-toluamide (DEET—mosquito repellent)

Improving Notification of Pesticide Poisonings

PURPOSE: This document is intended to assist health care professionals and environmental health practitioners in identifying the pesticide involved in suspected pesticide poisoning cases so as to improve on notification.

IDENTIFYING TYPE OF PESTICIDE(S) INVOLVED

The first health care professional to come into contact with a patient presenting with pesticide poisoning is required by law to notify the Department of Health (<http://www.doh.gov.za/docs/dns-f.html>).

Notify ALL pesticide poisonings regardless of the active ingredient. Do not report ONLY organophosphate poisonings.

Identify the pesticide involved and provide detailed information in the patient's file. Use the flow chart below:

```

graph TD
    Q1[Is there a label for the pesticide?] -- YES --> R1[Record the name of the product and the active ingredient in the patient's case folder]
    Q1 -- NO --> Q2[Does the caregiver/patient know the name of the product?]
    Q2 -- YES --> R2[Record name in patient's file]
    Q2 -- NO --> R3[Use point chart to identify and record in file]
    R1 --> Q3[Ask the following questions to caregiver/patient and put all details in patient's file:]
    R2 --> Q3
    R3 --> Q3
    Q3 --> R4[Use case-based form (GOW 1715 - notification of medical condition)]
    
```

Ask the following questions to caregiver/patient and put all details in patient's file:

- What form did the pesticide take? (e.g., granules, pellets, powder, liquid)
- Describe what the container looked like and what colour the pesticide was.
- Where was the pesticide purchased? Which store? Spaza shop? Street seller (e.g., taxi rank or informal market)?
- What was the pesticide used for?

Record all information in as much detail as possible so the National Department of Health (NDOH) can monitor the occurrence of pesticide poisonings, develop and implement intervention strategies and scrutinize the strategies effectiveness.

POISON INFORMATION CENTRES:


- Red Cross Children's Hospital Poison Info Centre: (021) 680 5227
- Tygerberg Poison Info Centre: (021) 931 6129
- Bloemfontein Poison Control Centre: 082 491 0160

For recognition and treatment of pesticide poisonings: <http://www.sgs.com/sgs00051005/active/active.html>


Produced November 2009

WHAT DID THE PESTICIDE LOOK LIKE?
Ask patient/caregiver to point to product involved

PYRETHROIDS




ORGANOPHOSPHATES:



Clear/Yellow—potentially methamidophos
White—potentially chlorpyrifos

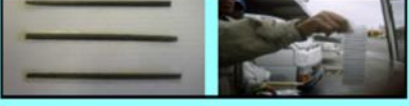
Acephate

ANTICOAGULANTS




Difethialone

CARBAMATE:




Aldicarb

ANTICOAGULANT



Brodifacoum

NAPHTHALENE



POINT CHART

Figure 1: CEOHR's Pesticide Notification guideline

The PNG provides a summary of the procedures that should be followed when HCPs are presented with poisoning cases, particularly when unlabelled pesticide product (that has no active ingredient of the pesticide is found on the label) is involved [7]. Initially, the PNG was available in the form of printed material only. The use of this guideline was found to be helpful among doctors working in Cape Town emergency medical units [8]. However, printed materials are not the most effective resources in these settings as compared to mobile applications which offer convenience and quick access to information in high-pressure situations [9]. As a result, the PNG developed by The Open Medicine Project South Africa (TOMPSA) was incorporated into the South African Emergency Medicine “EM” Guidance mobile application (Figure 2). The EM Guidance application aimed at HCPs provides immediate access to medical guidelines when providing care to their patients. The application consists of information for various medical specializations such as trauma, orthopaedics and toxicology (in which information on pesticide diagnosis and notification is found).

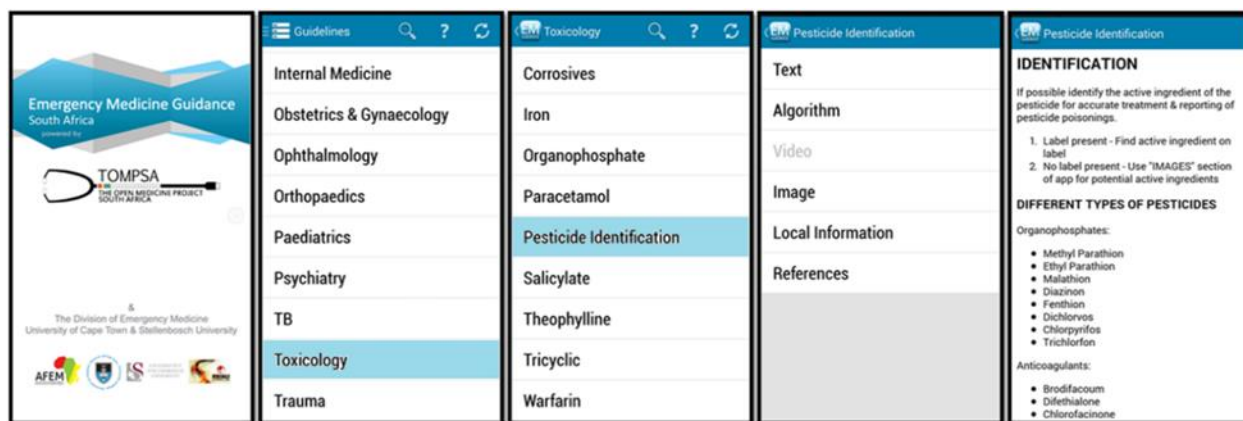


Figure 2: Screen shots of the EM Guidance application pages relevant for the CEOHR Pesticide Notification guideline

For the purpose of this thesis, the following terms are clarified:

Pesticide notification guideline (PNG) is the actual guideline that was developed by Associate Professor Rother and other stakeholders (including academic researchers, NGO and the SA government) at the University of Cape Town's Centre for Environmental and Occupational Health Research (CEOHR) as described in page A-4.

Pesticide notification guideline (PNG) within the EM mobile application is the application that contains the pesticide notification guideline.

With improvement in mobile technology, mobile health applications have become increasingly popular among HCPs because they are easy to use, convenient and accessible. Mobile health (mHealth) is the use of mobile technologies for delivery of health services [10], such as short message service (SMS) alert to improve health behaviours (treatment adherence, prenatal care alerts and among others). LMICs are faced with an increasing dual burden of non-communicable and communicable diseases [11] and mHealth (e.g. application-based and SMS-based approaches) are evolving as tools for creating cost-efficiencies, improving access to health care, and enhancing health systems' capacity to provide quality health care [12]. The use of mHealth is increasing in LMICs [13] particularly in sub-Saharan Africa countries (e.g. in Tanzania, Malawi, Mozambique and Ghana). Uses range from for educating individuals and communities about Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) and improving attendance to antenatal and neonatal care [14]. In LMICs mHealth has also been used to support HCPs in their clinical practice. For example, a study conducted in Botswana assessed the use of mobile learning by resident physicians [15] and found that mobile devices that had point-of-care tools (e.g. a drug reference) were effectively used by the physicians in resource-limited settings, for educational purposes/training and accessing medical information. Therefore, the use of mobile technologies has been demonstrated to provide educational support to HCPs in LMICs.

According to Kaplan [13], despite the great potential of mHealth to improve care in LMICs, its impact is limited, due to technical, socio-economic, cultural, and regulatory barriers. These challenges could possibly be tackled if technology applications or solutions are aligned with LMIC settings. Another issue is that there is not enough justification on the effect of mHealth applications for the control of diseases in LMICs [14, 16, 17]. Further research is required to evaluate mHealth technologies towards health outcomes and quality of care in LMICs. This study, will assess the EM Guidance mobile application containing the pesticide notification guideline, and contribute towards bridging the gap in literature – of evaluating mHealth technologies in LMICs. The study will evaluate the acceptance and use and relevance of the tool among HCPs working in South Africa. Specifically, documenting HCPs’ attitude towards the mobile application and its information (the pesticide diagnosis and notification guideline section) to establish whether it is a useful PNG for enhancing learning and assisting in improving diagnosis and notification of pesticide poisoning cases.

1.2. Problem statement

Several studies in high income countries [5, 18, 19] and some LMICs such as Tanzania [20] and SA [7] indicate that most HCPs feel their medical training has not effectively prepared them to address environmental health issues (e.g. lead poisoning and environmental exacerbation of asthma or pesticide exposure) in their clinical practice. In addition, there is limited quick- access information for HCPs to improve diagnosis and notification of pesticide poisoning cases. Currently, HCPs refer to the internet for information or depend on poison information centres that assist HCPs in addressing pesticide poisoning cases. This presents a challenge to HCPs when diagnosing and notifying of pesticide-related exposures or concerns. For example, in SA, healthcare professionals would need to call the Tygerberg poison information centre to assist them in managing poisoning cases [21].

The use of mobile applications is convenient, easy to use and accessible and becoming popular among HCPs [22, 23] in comparison to printed materials, working on a laptop or desktop computer or calling the poison information centres. With the use of the developed PNG within the mobile application, HCPs could have a convenient tool that could improve their ability to accurately diagnose and ensure notification of APPs. This may contribute to more effective surveillance and control of pesticides. Thus, this study is motivated by the need to evaluate the acceptance or use of the current South African PNG within the EM mobile application, for assisting HCPs in improving diagnosis and reporting of APPs.

1.3. Theoretical framework

This research will be guided by both the theory of planned behaviour (TPB) and social cognitive theory (SCT) to investigate the acceptance/use and factors that influence the acceptance of CEOHR's PNG within the EM mobile application as an educational tool. The TPB has been used to understand the determinants (e.g. attitude) of HCPs' behaviour on the use of new techniques and information within health care settings [24-27] in different countries (e.g. in the UK, Thailand and Belgium). A study conducted in the UK examined general practitioners' (GPs) belief and intentions when prescribing antibiotics to patients with sore throats despite the knowledge that antibiotics are ineffective and could result in bacterial resistance. The study found that attitudes and perceived behavioural control were important predictors of intention. That is, GPs with negative attitude about antibiotics displayed better control in prescribing, and this depends on their intention. In their study, the GPs had weak intention of prescribing antibiotics. Hence, the theoretical frameworks demonstrate which beliefs held by the GPs affect their drive to prescribe antibiotics. These belief systems should be targeted in the future campaigns to decrease over-prescription of antibiotics.

The TPB states that intention is the central determinant of the behaviour [28]. The intention can be influenced by three constructs namely, attitudes, subjective norms and perceived behavioural control. In

essence, the TPB appears to be important in understanding HCPs' behaviours in order to understand whether mobile applications are an effective mechanism to promote behaviour changes.

In addition, the SCT could also be used to assess the behaviour intentions of HCPs in relation to mHealth technologies. According to SCT, there are three factors that affect the probability that an individual will change their health behaviour. These are: self-efficacy (a person's confidence in performing a particular behaviour, which is considered the main determinant in behaviour change); goals (which serves as a guide for an individual to achieve a particular behaviour); and outcome expectancies (about the advantages and disadvantages of performing the behaviour) [29]. Furthermore, knowledge and skills, perceived facilitators and impediments (e.g. difficulties faced in understanding or using the pesticide guideline within the EM Guidance application) are other factors that could influence a person's behaviour [30]. Thus, in this study to evaluate the acceptance, use and factors that influence the uptake of the PNG within the EM mobile application for HCPs, these two theoretical frameworks will be used to guide the research.

1.4. Justification/ gaps in the literature

Several studies have evaluated the acceptance, use and factors that influence the uptake use of mobile applications by HCPs, mostly in high income countries, and the findings generally indicate that mobile applications facilitate HCPs' effectiveness in executing clinical tasks, decision-making and provide support for their patient health care education [31, 32]. For example, studies conducted by Payne et al. [31] and Man et al. [32] in the United Kingdom (UK) and the United States (US), respectively, found that a mobile application saved HCPs' time during clinical activities, reduced the time to refer to hospital clinical guidelines and manuals and improved their confidence level in treating medical conditions (e.g. depression). However, there is limited research that has evaluated the acceptance, use and factors that influence uptake of mobile application use by HCPs in LMICs where there is rise in the use of mobile

applications among HCPs. This concern was also mentioned by O'Donovan et al. [33] who indicated that mHealth could be an effective tool to assist HCPs' clinical training and tasks. Furthermore, the authors indicated that quantitative methods are required to show mHealth is efficient in health care. In this proposed study, a quantitative method (an online questionnaire) will be used and this could contribute to examining the potential of mHealth. This study will therefore add to the literature on mHealth, particularly in relation to understanding the acceptance, use and factors that influence use of mobile applications for HCPs from LMIC perspective. In addition, provide information concerning the use of mobile applications for diagnosis and notification of APPs where there is dearth of research.

As a result of this study, recommendations will be provided to describe ways the EM Guidance developers could improve the PNG within the EM mobile application in the future.

1.5. Aim and objectives of the study

1.5.1. Aim

The aim of this study is to evaluate the CEOHR's pesticide notification guideline within the EM mobile application as a tool for improving healthcare professionals' ability to diagnose and report pesticide poisoning cases.

1.5.2. Objectives

In order to inform the research aim, this study will attempt to address the following objectives:

- To evaluate South African healthcare professionals' current understanding of pesticide poisoning as a notifiable medical condition.

- To assess the use of the PNG within the EM mobile application and its impact in providing support for diagnosing and notifying pesticide poisoning cases seen by emergency medical professionals.
- To identify ways in which the PNG within the EM mobile application could be improved in order to enhance its effectiveness and applicability.

1.6. Research question

The following main research question to be addressed in this research is:

How useful has the pesticide notification guideline within the EM Guidance mobile application been in improving healthcare professionals' ability to diagnose and report pesticide poisoning cases?

Additional sub-research questions to be addressed by this study include:

- Are healthcare professionals aware that pesticide poisoning is a notifiable condition?
- What are healthcare professionals' knowledge, attitude and behaviour concerning the use of the mobile application and the PNG within the EM mobile application?
- For what purposes do healthcare professionals use diagnosis and notification section of PNG within the EM mobile application in their medical practice?
- How did the use of PNG within the EM mobile application assist or improve healthcare professionals' skills and knowledge in diagnosis and notifying pesticide poisonings?
- What aspect of the PNG within the EM mobile application is most useful and least useful during practice?
- What do healthcare professionals see as the advantages and disadvantages of using the PNG within the EM mobile application?

- How has the use of PNG within the EM mobile application contributed in better diagnosis or notification of pesticide poisoning cases?
- How can the PNG within the EM mobile application be enhanced?

2. Methodology

2.1. Study design

A descriptive survey will be conducted over a period of three months with emergency medicine registrars and physicians across SA. Both qualitative data from open-ended questions and quantitative data from closed-ended questions will be collected through an online self-administered questionnaire.

2.2. Study population and sampling

The study population will be all the current emergency medicine registrars and physicians who are practicing in SA. These participants will be purposively sampled and then invited to participate in this study. Seventy-three potential participants will be approached to participate in this study. However, it should be noted that a large number of participants are expected to be from Cape Town, since the Division of Emergency Medicine there is the largest in SA [34].

Cape Town participants will be contacted with the aid of an emergency medicine registrar, and other participants will be contacted using Medpages Directory. The participants will be recruited through email contacts and telephone calls. The mailing addresses, as well as telephone contact information, of the participants outside of Cape Town will be obtained from the Medpages Directory website and assistance from EM registrars in Cape Town.

The participants will be informed of the study through email, one week before the study begins. Follow-up email reminders will be sent to non-respondents. The eligibility criteria for the study will be emergency medicine registrars and physicians working in SA, because the EM Guidance application was designed for them to assist in diagnosis and notification of APPs. Furthermore, the eligibility criteria needed participants that were willing to partake in the research. The exclusion criteria will be health professionals who are not emergency medicine registrars and physicians and incomplete questionnaires.

2.3. Data collection

2.3.1. Survey instrument

Data will be collected through an online questionnaire built by the researcher. An online survey tool (SurveyMonkey) allows busy emergency medicine registrars and physicians to complete the questionnaire in their own time. The self-administered questionnaire will be developed in collaboration with the researcher's academic supervisor and the developer of the EM Guidance application. The questions will be informed by the TPB, the SCT and the relevant literature (e.g. the study by Payne et al. [31]). The questionnaire will be administered in English. A pilot study will be conducted with five non-emergency medicine physicians before the study commences. This is to ensure the validity and reliability of the questionnaire, which will then be updated accordingly.

The questionnaire (Appendix A) will consist of both open and closed-ended questions capturing demographic information (e.g. age, gender and profession), healthcare professionals' understanding of pesticide poisoning as a notifiable medical condition, use of PNG within the EM mobile application healthcare professionals. In addition, it will include an evaluation of the PNG within the EM mobile application and how it could be enhanced will be included.

2.3.2. Data management and analysis

The data that will be collected through a SurveyMonkey questionnaire will be imported and analysed using STATA statistical software, version 12 [35]. Descriptive statistics will be used for the analysis of the quantitative data. The qualitative data obtained from open-ended questions will be analysed using thematic analysis, a method that is used to identify, analyse and explore themes within the data [36]. This involves filtering through the data to discover any emergent frequent themes. In addition, this method has the ability to detail people's experiences and perspectives, and the meanings and realities of those experiences. Thus, for thematic analysis, step-by-step guidelines will be followed, which will include (a) Being familiar with the emerging data, (b) producing first codes, (c) examining for themes, (d) rereading themes, (e) designating and naming themes, and (g) producing findings of the research.

2.4. Study timeline

2.4.1. Timeline

The table below (**Table 1**) illustrates the proposed study timeline requirements for the achievement of tasks associated to the research and completion of the mini-thesis.

	January 2015 – September 2015	October 2015	November 2015	December 2015 – February 2016	March - October 2016	April 2016	May 2016 – February 2017	March 2017
Research protocol development								
Literature review								
Develop questionnaire								
Ethics review								
Data collection								
Data analysis								
Write-up								
Submit thesis								

Table 1: Timeline for completion of mini-thesis

2.5. Limitations

The limitation of the study is that the sample size is small given that there are few emergency medicine staff. Nevertheless, the study will give a glimpse of understanding the effect of PNG within the EM mobile application in assisting emergency medicine registrars and physicians to diagnose and notify APPs. Future studies would benefit from conducting in-depth interviews. However, the qualitative component of this study's questionnaire will still be able to offer a preview on professionals' perspectives on the use of PNG within the EM mobile application.

3. Ethics

Ethics approval will be obtained from the Faculty of Health Sciences Human Research Ethics Committee at the University of Cape Town.

3.1. Description of risks and benefits

Participants in the study will be informed that there will be no direct personal benefits for participating in the research study. However, the researcher will be giving information to the participants that may be of benefit to their future practice. There are no foreseen risks or harm for participating in the study, however, attention will be paid to any unexpected issues that may arise in the study.

3.2. Informed consent and process

Before the study begins, participants will be emailed with information that will explain all aspects of the research study. The participants will also receive a link to the online survey. On the first page there will be an information sheet in order to obtain consent (text in Appendix B). Once the participants have consented to participate in the study by ticking the circle at the bottom of the consent page, the first page of the questionnaire will appear. They will also be informed that they can withdraw any time during the study. Participants will also be given the opportunity to ask if they do not understand or need clarification about the study before answering the questionnaire. This will be achieved by either contacting or emailing the researcher or the study principal investigator.

3.3. Privacy and confidentiality

All the information gathered in the study will be treated as confidential. The only people that will have access to the data will be the researcher and thesis supervisor. The participants will not be asked to provide their names or other personal information. Thus, participants' identity will remain confidential throughout their participation in the study. Personally identifiable information will not be disclosed in the publications or presentations. Data will be kept electronically on the researcher's personal computer that has a protected password until it has been published in a peer-reviewed scientific journal, and will be destroyed afterwards.

3.4. Dissemination of study results

The findings of this study will be presented in a mini-dissertation to fulfil the requirements of the MPH, in an article submitted to a peer-reviewed scientific journal, and will also be presented at an appropriate conference.

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PART B: Literature Review

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1. Introduction

Pesticides are commonly used worldwide and agriculture accounts for most of the pesticide usage in African countries including South Africa (SA) [1, 2]. Further uses of pesticides in SA, include control of disease vectors and domestic pests [1, 3]. These vectors and pests are of concern as they pose significant public health risks [4]. Pest infestation is a common occurrence in low socioeconomic urban communities mostly due to sub-standard living conditions – such as poor housing, overcrowding and inadequate sanitation [3, 5]. As a result, residents rely heavily on cheap and illegal pesticides for pest control.

Illegal “street pesticides” are made up of active ingredients registered for agricultural purposes only, due to their high toxicity. Aldicarb, for example, also known colloquially as “Two Steps” in informal markets as that is all the rat can take, is so highly acutely toxic that a 60 milligram (mg) sachet could kill six children who weigh ten kilogram (kg) or less [4]. These pesticides are often decanted into unlabelled containers and sold for domestic use by areas such as train stations and open markets [5, 6]. Their use has been reported in both high income countries and low -and middle-income countries (LMICs) [4, 5] and with high use mostly in poor urban communities [7]. As a result, it becomes challenging for healthcare professionals (HCPs) to link poisoning cases to unlabelled street pesticides as illustrated in a South African study [6].

In South Africa, HCPs play a key role in health surveillance and are required to notify all acute pesticide poisonings (APPs) as these are notifiable medical conditions [3]. However, notification of APP cases is poor for several reasons, including HCPs’ failure to diagnose correctly and/or only reporting organophosphate (OP) poisonings rather than the full spectrum of pesticide classes (e.g. carbamates, organochlorines, rodenticides and pyrethroids) [6]. As a result, there is under-reporting of APP cases in SA which prevents

the effective risk management by the government. It has also been indicated that most HCPs have limited training in addressing environmental-related cases, such as APP [6]. In addition, there is limited easy access to information that supports HCPs to improve notification of APPs, especially in terms of identifying and reporting street pesticides.

With the increased use of smartphones in the workplace, a medical application could be a useful information provision tool for HCPs to easily access materials such as pesticide notification guideline while in clinical practice. The advantages of mobile applications over other resources [i.e. printed or hard copy materials] is that they are convenient and can easily access information at point-of-care in high-pressure situations such as the emergency department [8]. Therefore, the University of Cape Town developed an algorithm/point chart (pesticide notification guidelines; [6]) that was adapted and added to a mobile Emergency Medicine (EM) Guidance application to provide HCPs with an easily accessible tool to assist them in diagnosis and notification of APPs [9].

This study focuses on evaluating the effectiveness of the PNG within the EM mobile application, for HCPs to improve diagnosis and notification of APPs.

The objectives of this literature review were:

- To review the worldwide literature on pesticide poisoning and health effects to assess the main problems for LMICs.
- To document key challenges with pesticide poisoning surveillance systems in LMIC, and HCP training and knowledge base on pesticide poisonings.
- To determine the role medical mobile applications play upon the working activities of healthcare professionals in clinical/hospital settings.

- To identify relevant theoretical frameworks for understanding healthcare professionals' behaviour changes (e.g. attitude and self-efficacy) in relation to the application of clinical guidelines or algorithms within clinical practice.

2. Literature search strategy

Literature was obtained from the following online databases; Google Scholar, Science Direct and PubMed.

A selection of references cited in the included publications was also searched to identify additional relevant information. Information obtained from grey literature, such as websites and newspaper articles were also considered. Studies on pesticide poisoning, behavioural theoretical frameworks, mobile health and research carried out in both LMICs and high income countries were included. Approximately 450 articles were retrieved and selected 200 on the basis of title and abstract. However, some articles were excluded after reading the full text on the basis of quality of the article and irrelevance to this study. Only articles in English were included.

The search terms used were: pesticide poisoning; health effects of pesticides; pesticide poisoning and surveillance; healthcare professionals and pesticide poisoning; training and healthcare professionals and pesticide poisoning; healthcare professionals and clinical guidelines and behaviour; mobile health and LMICs, mobile health and healthcare professionals, mobile applications and healthcare professionals, emergency medicine and South Africa.

3. Summary of literature

3.1. Acute pesticide poisoning (APP) and health effects

APP is a significant global public health issue, particularly in LMICs [10, 11]. World Health Organization (WHO) approximated that three million of APP cases happen every year and, of these, a minimum of 300 000 result in fatalities [10]. The true burden of pesticide related illness or fatalities is unknown since most APP cases are unreported or undiagnosed [10, 12]. Pesticide fatalities are due to intentional (self-poisoning), unintentional (accidentally consumed or applied) or occupational pesticide exposure. However, the majority of these deaths results from pesticide self-poisoning [10], particularly in LMICs such as Sri Lanka and China [13, 14]. At a global level, it is estimated that there are approximately 258, 234 annual deaths from pesticide self-poisoning worldwide [15]. This could be attributed to easy availability of toxic pesticides, especially in LMICs where there are no effective restrictions or regulations.

Furthermore, the literature attributes to limited access to personal protective equipment (PPE) and weak regulatory frameworks which increases the possible risk of hazardous exposures among end-users [16]. Farmworkers are at greater danger of being exposed to dangerous pesticides in comparison to non-agricultural workers [13]. A Ugandan study found that there was improper use of moderately and highly hazardous pesticides among potato farmers, linked to weakness of pesticide regulatory bodies. In addition, the study found that 43 percent of the farmers interviewed experienced acute symptoms such as skin itching, burning sensations and dizziness, due to repeated exposure to pesticides with low use of PPE [17]. Similarly, in a Lesotho study, the majority of farmworkers did not use PPE when handling pesticides due to the fact that 93% lacked training on the use of pesticides [18]. As for the other farmer

workers, it is poor education that makes it challenging for them to interpret the details on pesticides labels and, therefore it is problematic for them to understand the dangers associated with pesticides [18]. The use of pesticides poses a substantial acute and chronic health threat to farmworkers that may result in health problems such as eye irritation, skin rashes, cancer and neurologic disorders [18, 19]. These health effects resulting of pesticide exposure depends on the toxicity and the dose absorbed [20]. A number of studies have been conducted to assess the relationship between pesticide exposure and health effects outcome [21, 22, 23].

For example, a study conducted in India assessed the functions of the lungs, respiratory health conditions, levels of cholinesterase and hematological profile amongst pesticide sprayers. The findings showed that the study participants exposed to OP pesticides had respiratory diseases and hematological abnormalities [21]. A study in SA found that female farmworkers exposed to pesticides were at a high probability of developing symptoms of asthma and ocular-nasal [22]. In another study conducted among 1379 Brazilian agricultural workers showed that exposure to pesticides increased their respiratory symptoms [23]. Such studies demonstrate the hazards faced by end-users particularly in LMICs and, requires application of preventative measures (i.e. training in safe handling and use of pesticides). The evidence of unsafe use of pesticides or poor knowledge of the risks has also been reported in Jamaica [24], Ghana [25] and Egypt [26] indicating that it is a problem in LMICs.

Several efforts have been implemented around the world in order to reduce the incidence of or deaths resulting from APP, including restricting access to toxic pesticides, implementing surveillance systems, and improving medical treatment of APP [11, 14, 27, 28, 29]. However, these have had limited success. Furthermore Goal 3 (target 3.9) specifically of Sustainable Development Goals (SDGs) focuses on the

reduction of the number of deaths and illnesses from hazardous chemicals (e.g. pesticides) by 2030 [30]. It is, therefore, important that an effective surveillance of APP exists in countries where pesticides are extensively used.

3.2. Surveillance of pesticide poisoning

Surveillance is considered to be an important public health tool, particularly for the prevention of APP [31]. Surveillance data provides the basis for planning, implementing and evaluating public health control measures. Essentially, surveillance of diseases is important for an effective and prompt health delivery services and also provides good strategy of transforming health policy [32].

In the past years, there has been an improvement in the surveillance of pesticide-related diseases in LMICs, although many LMICs still lack appropriate surveillance systems [31, 33, 34]. Most LMICs fail to implement good surveillance systems due to barriers such as lack of human and material resources, weak infrastructure and poor coordination (e.g. nonparticipation among private health care providers), and uncertain linkages between surveillance and response [35].

Globally, there are several data sources for pesticide poisoning surveillance. These sources include but are not limited to: poison control centres (PCC) or poison information centres (PIC); workers' compensation data, emergency department logs, hospital discharge data and laboratories, and healthcare professionals [36, 37-39]. HCPs play a vital role in disease surveillance as they are the first to attend to patients and identify APP cases. Their role has been seen in high income countries such as the US [36], as well as in some LMICs in Central American countries [32] and SA [31].

In SA, HCPs are required by law to report any APP to the national Department of Health (DOH) [6]. It is their responsibility to fill in the GW17/5 form (notification form for cases and deaths) which is then submitted to the local or district health service, to inform of the condition that requires an appropriate response [40]. However, APP in SA is widely under-reported and it is estimated that only 10% to 20% of hospitalized cases and 5% of mortuary cases are reported [3, 31]. It is suggested that poor coordination of different information systems could be among the reasons of under-reporting [31]. In other instances, such as in SA, only organophosphate-containing pesticides (OP) are mostly being reported, and poisonings by other pesticides for example carbamates and coumarin rodenticides are not seen as relevant to report [3, 5]. A similar magnitude of under-reporting has also been observed in other African countries, such as in Tanzania where a study found that 78% of cases presented to health facilities go unreported in hospital information systems [41]. This was due to poor recording systems. The low reporting has similarly been noted in Nigeria, where APP is not recognized as a notifiable condition [42]. However, the Nigerian study [42] reviewed above had errors such as some of the texts did not have references, and it did not discuss any limitations of the study. Even though countries such SA recognize APP as a notifiable condition, the law has not shown to have an impact on reporting. This shows that the legal requirement of reporting all APPs may not be effective and, that HCPs need more support for notifying APP cases as this could possibly make the law more actioned and effective.

While the above literature shows that there is poor notification of APPs in Africa, there seems to be an indication that this is a problem for many LMICS. For example, in Nicaragua, one study found a significant under-reporting of APP cases, with few being notified (i.e. less than five percent) [43]. This was attributed to physicians failing to report APP cases due to the lack of printed forms, limited time, and/or poor awareness about the prerequisite reporting forms despite treating the affected individuals [43]. Another

reason was the treatment of APP cases notified by HCPs were not recorded in surveillance system, as a result some of the details get lost in between during data transmission [43]. This could also be an issue in other LMICs. Therefore, an effective, stable and reliable surveillance system is required to address the problem of underreporting - especially in LMICs where exposure to pesticides and its hazards are high. In addition, HCPs should be sufficiently trained in identification and notification of all pesticide classes to improve on and support surveillance systems.

3.3. Healthcare professionals' pesticide knowledge and training

The environmental health education component in HCPs medical training globally is limited [44, 45]; that is, training on environmental identifying health risk factors (e.g., lead poisoning, APP, air pollution), treatment and prevention. In 2006, a study conducted in the US found that HCPs lacked basic training and knowledge in pesticide exposure [46]. These findings are similar to studies conducted in Kenya [47] and Tanzania [48], where HCPs were observed to be ill-equipped to provide appropriate care to patients with APP. A descriptive epidemiologic study conducted in Kenya showed that more than 40% of HCPs could not recognise APP cases [47]. As for the Tanzania study, only one percent of HCPs could identify the different pesticide groups [48]. This highlights the need to improve HCPs' knowledge and training on pesticides to reduce pesticide-related illnesses or deaths, and improve on surveillance of these cases.

In South Africa, Rother [6] ascertained that HCPs face difficulty in diagnosing APP linked to pesticide products that are unlabelled, illegal and have unknown formulations or concentrations. This is likely to be

experienced by HCPs in other countries where the use of unlabelled street pesticides is also a problem [49].

Rother [6] developed a limited quick access to resources for HCPs to improve notification of APP cases. Current practices in LMICs such as SA, Pakistan and Kenya include HCPs searching for information on the internet or consulting with PICs for help in the identification and notification of APPs [50-52]. Others tend to rely on manuals available in the hospital facilities. Many of these practices can be time consuming for busy HCPs as observed in a Pakistan study, where doctors spent more than 15 minutes searching for drug or poisonous substances information while managing a case [53]. This may result in the delay of medical care and increase the risk of adverse clinical outcomes for patients [53]. Therefore, it is hypothesized that a smartphone or mobile health (mHealth) applications may provide a timely and innovative approach to assist and educate HCPs on pesticides and in improving their notification of APPs on site, especially in LMICs.

3.4. Mobile health applications and HCPs

mHealth is a rapidly growing field that uses mobile technologies in healthcare [54, 55]. Mobile technologies include mobile phones, personal digital assistants (PDAs), PDA phones and smartphones [55]. These devices can be used for short communication through messages, photos, and software application support. The software applications are types of programs developed to operate on mobile devices or tablet computers [56, 57], to support HCPs in clinical decision making, communication with patients and among others.

According to Masters [58], approximately 60-70% doctors have access to internet and therefore can search for or get information (i.e. emails, journal, medical databases, download mobile application and etc.) on their mobile phones at any time. In another study conducted by Masters [59] among South African GPs, it showed the percentage of GPs accessing internet in various locations, with 82% accessing at home and 72% in their clinical practice or hospital. Therefore, it is possible that HCPs have good access to internet at the locations when they require it, particularly in their clinical work.

The use of mHealth technologies to support HCPs in their medical practice (e.g. in diagnosis and patient management, or for education purposes) has seen significant growth and popularity worldwide, due to the increasing availability and quality of medical-related mobile applications [55, 56, 60]. In addition, HCPs are able to carry clinical or medical manuals on their mobiles, for reference anywhere at any time. In a US study conducted in 2012, the most popular categories of mobile application uses amongst HCPs included tools for drug-referencing and supporting clinical decision-making, communication (i.e. communication among HCPs or with patients), accessing electronic health records and medical education materials [61, 62]. Drug reference guides (e.g. 'Epocrates, Inc.' and 'Lexiomp') and clinical decision-support tools (e.g. as 'Medscape' and 'UpToDate') were the top applications among HCPs in the US [61, 62]. Other studies conducted in the US and the United Kingdom (UK) found that 85% to 99% of doctors own smartphones respectively [63, 64]. More than 50% of both US and UK doctors reported using their smartphone/mobile applications in their clinical practice [63, 64]. Although there are limited studies that have investigated use of mobile applications among HCPs in LMICs particularly in Africa, one study conducted in Botswana assessed the utilization of mobile learning among resident physicians [65]. The resident physicians based at public hospital were provided with smartphones which were effectively utilized in accessing medical information at the point-of-care and for educational purposes [65]. However, the Botswana study [65]

investigated physicians who received prior training on how to use smartphones loaded with medical resources making the results not generalizable to HCPs who use mobile devices without prior training for medical or education purposes.

Another study conducted in Ethiopia assessed smartphone mobile applications that were previously developed to fulfil the necessities of community health workers for maternal health services [66]. It was an observational research study that followed 32 participants for eighteen months. The study found that most of the health workers adjusted quickly and were comfortable in using the smartphone technologies for maternal care. In addition, the study found that mobile technologies could allow health workers to access data fast and detect problems within the health services [66]. This Ethiopian study gives an insight on the usefulness and potential of mHealth technologies to support health workers especially in a LMIC context, making the study significant and relevant to this research. The limitation of the Ethiopian study, however, is that a small number of health workers and health facilities were enrolled. Nonetheless, the study emphasised that strong possession of mobile phones among health workers is essential for an effective mHealth program [67]. This is important to note especially in LMICs, where some HCPs in rural or remote areas have not yet become familiar with mobile technologies. Therefore, a mobile application may be a means to promote HCPs in LMICs to adhere in notifying APP cases and improve its diagnosis, particularly from unlabelled and illegal pesticides.

The field of mHealth is gradually being adopted in LMICs countries [67], due to its potential of improving healthcare particularly in limited-resource settings. However, there are technical and administrative challenges related to mHealth that are faced in these countries [68]. The technical challenges include poor access to broadband internet, guaranteeing the privacy of a patient during wireless transmission, usage

concerns, and issues of both data and mobile phone security [68]. As for the administrative challenges for mHealth in LMICs, they include insufficient strategic leadership, difficult learning environments and limited buy-in from intended users such as HCPs, and limited readiness to use mobile technology [68-70]. This demonstrates the need to take context into account when introducing mHealth interventions to mitigate against complications to implementation. Therefore, mHealth solutions should be created in collaboration with technology system designers, health policy makers and, HCPs to enhance the level of mHealth adoption and sustained use in LMICs. It would also be useful for mHealth to be integrated into healthcare systems, as a new way to improve health outcomes and assist HCPs in their daily tasks.

Despite the benefits associated with the use of mobile applications, there are some further limitations which need to be noted. The hardware of smartphones has been posed as an issue, such as the small screen size, limiting the amount of information that can be displayed at one time. In addition, slow download speeds may prevent users from downloading or using the mobile application [71, 72]. This could be a problem for busy HCPs as such issues may delay their clinical-decision making at the point of care. Organisations may also have policies preventing or restricting the extensive use of mobile devices in the working environment [73, 74]. In addition, there is concern about the reliability and accuracy of the software platforms [75]. The latter issue could be since most of the medical applications that are produced are rarely reviewed or validated. Such constraints could also be faced in LMICs [76]. However, a number of possible solutions have been proposed to increase the accuracy and reliability of mobile applications, such as involving clinicians to review the medical applications or launching a medical application certification program that addresses issues of operability, security, and content [77]. To improve the efficiency and accuracy of mobile applications in LMICs, it requires buy-in support from the health system and involvement of HCPs as mentioned above.

Another limitation concerns large number of mobile health applications available for HCPs, because it is challenging for HCPs to identify the correct medical application for their clinical practice or educational purposes. Van velsen et al. [71] mention that when medical professionals or citizens are overloaded with health applications, it limits their usefulness. This is due to the fragmentation of information or difficulty in finding the right mobile health application. Although van Velsen et al. [71] proposed ways in which application overload could be solved (e.g. standardizing the medical content across all applications), there is still need for future considerations on how information should be presented in the mobile applications, to avoid application overload.

3.5. Mobile application use for managing pesticide-related cases

There are not many mobile applications available to assist HCPs in clinical decision making linked to the diagnosis, treatment or notification of APP cases. A number of pesticide related mobile applications focused on protecting workers and farmers [78, 79]. For example, a “Pesticide label” mobile application that was recently launched in Canada aims to help the general public (e.g. homeowners, farmers and industry) by searching for specific pesticide label instructions/labels on their mobile smartphone or tablet devices [78]. This approach is convenient because most users are assumed to be able to access pesticide product information on their mobile phones to protect health and environment. A recent study conducted in the US by Snipes et al. [79] investigated the feasibility of ¡Protéjase!, a mHealth platform intended to encourage utilization of PPE among Mexican farmworkers. The intervention platform was designed to promote pesticide safety for Mexican and Mexican-American farmworkers. Results from their study showed that the ¡Protéjase! mHealth program revealed the usefulness and approval among the

farmworkers. Furthermore, the utilization of mHealth was seen helpful in encouraging the use of PPE among farmworkers. The study findings of Snipes et al. [80] provided an insight regarding the importance of mHealth as a platform in promoting pesticide safety among farmworkers, making this study important. That is, using mHealth platform in this case the PNG within the EM mobile application to promote and assist HCPs to notify APP cases. However, the study from Snipes et al. [79] had a small sample size, and it remains to be shown that similar results can be achieved on a larger scale. Nevertheless, their study had a higher overall follow up rate (75%), clearly stated their objectives and defined the study population. It would have been useful for the authors to mention the inclusion and exclusion criteria [79].

There have been studies assessing other forms of educational tools for HCPs to use such as manuals or printed copies and web-based materials [46, 80, 81]. For example, one study in the US identified several internet (web-based) resources (i.e. <http://www.cdc.gov/niosh/topics/pesticides/>, <http://oregonstate.edu/npmmp/>) that HCPs could use to correctly identify pesticide hazards and acquire information about diagnosis and treatment [81]. The inability of the HCPs to manage or link pesticide poisoning to unlabelled pesticide product is a challenge, particularly in the case of street pesticides making web-based resources useful in assisting HCPs with such difficult cases.

To the researcher's knowledge there is no research that has investigated the use of mobile applications for assisting HCPs in improving the diagnosis and notification of APP cases in particular. The Open Medicine Project from SA (TOMPSA) developed an application containing UCT's pesticide identification guideline and shows promise in assisting HCPs with diagnosis and notification of APP cases (**Figure 1**) [9]. However, no previous studies have evaluated the tool. For this reason, this study was undertaken to

evaluate the PNG within the TOMPSA EM Guidance mobile application in assisting HCPs with the diagnosis and notification of APPs.

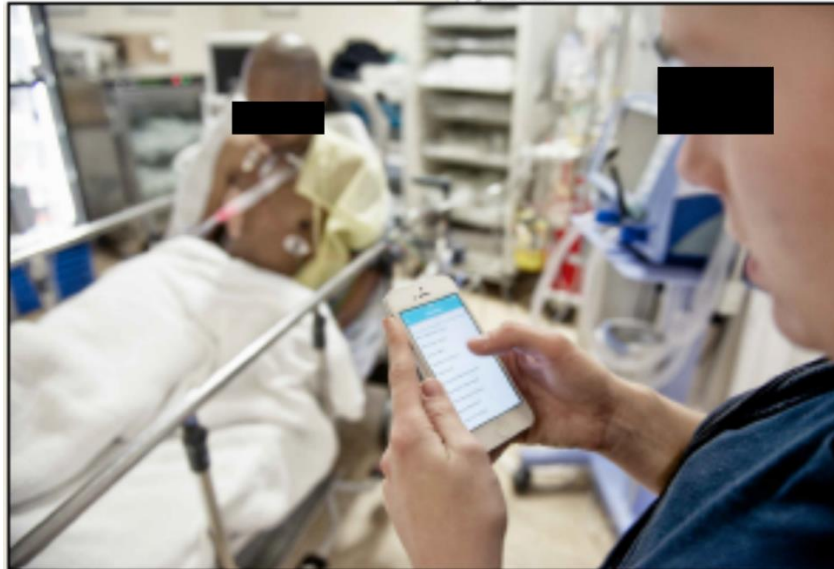


Figure 1: South African EM registrar using the pesticide guideline within the EM Guidance application on a smart phone, Rother et al [9].

3.6. Evaluating mobile health applications for HCPs

Several studies have been conducted to evaluate medical applications targeted at and used by HCPs [74, 82, 83]. Payne et al. [82] conducted a pilot study with 39 junior doctors in the UK, where they investigated the effect of a mobile smartphone application. The authors produced the application called '*iTreat*' which mainly consisted of disease management and guidelines for antibiotic dosing. It was reported that most doctors felt the application was effective and time-saving, and reduced the need to refer to hospital clinical guideline manuals [82]. However, some doctors responded negatively toward the use of the application. They thought that it was unprofessional to use mobile device applications within the hospital setting. Since the study of Payne et al. [82] used a hospital-specific application, the results might not be

generalizable to other countries (or even to other hospitals). Still, this was a well-conducted study which explained and justified the methodology and discussed the limitations.

In a similar study, also conducted in the UK, Davies et al. [74] reported that some participants felt it was unprofessional to use mobile devices during patient consultations. Nevertheless, their study found that most of the participants were in favour of mobile application use in healthcare. Their study had a clearly defined objective with a sample size of 211 research participants. However, it might have been helpful for the study by Davies et al. [74] to include the rationale for the sample size, details of the inclusion and exclusion criteria and discuss limitations related to their study. The studies discussed above provided some insight on how the hospital environment has a negative impact on the use of the mobile application among HCPs. Therefore, it was important for our study to assess the suitability of use of mobile applications within hospital settings or during patient consultations.

In a pilot study conducted in the US, Man et al. [83] assessed the effectiveness of a mobile application among 14 physicians for guiding antidepressant drug selection. It is important to note that their sample size was small. Nevertheless, their prospective study focused on the effect of mobile applications among physicians' level of confidence when managing patients with depression. The authors found that the physicians' confidence levels in managing patients with depression increased significantly within the period of using the mobile application. Therefore, this study aimed to determine whether the use of pesticide-specific mobile application increases the confidence of HCPs in correctly diagnosing or notifying APPs. Furthermore, Man et al. [83] highlighted the application's effectiveness in educating physicians whose busy schedules prevented them from reading or keeping up with practice guidelines. This illustrates that mHealth provides a good platform for HCPs to be up-to-date or aware of the current or upcoming

clinical guidelines (i.e. pesticide notification guideline). Man et al. [83] study clearly indicates the inclusion criteria, however, it would have been useful for them to give details on the exclusion criteria.

A review published in 2015 evaluated most useful dermatology-related applications for HPCs to enhance the prevention and early diagnosis of skin cancer [84, 85]. The authors presented the advantages (e.g. simplicity and quick access to information) and disadvantages (e.g. applications that are limited to particular countries or states) associated with the use of studied applications. This is important, especially now that there are numerous medical applications available, making it difficult for HCPs to identify the most suitable applications. However, the authors do not specifically mention their research approach on assessing the useful dermatology-related applications.

In summary, the literature reviewed generally indicated that mobile applications are effective and useful for training and professional development among HCPs beyond medical school, despite some disadvantages (e.g. small screen size). Several concepts assessed in the literature included: impact upon working activities (e.g. impact of the application on patient care and clinical work), application functionality (e.g. ease of use, usefulness found in each section of the application), barriers to use of mobile applications, confidence in managing health conditions with the support of an application and other issues. Most of the studies discussed in section three were carried out in high income countries, as there is scarcity of evidence about their use in LMICs. In addition, there is a lack of evidence from LMICs regarding HCPs' view on using mobile applications linked to environmental health concerns (e.g. APPs). Therefore, it was useful to assess some of the above-mentioned concepts in this study, from a LMIC perspective. Hence, this study aimed to evaluate the acceptance, use and factors that influence the use of mobile application for diagnosis and notification of APPs among HCPs in LMICs.

3.7. Theories of behaviour change among HCPs

Guidelines have been developed to assist HCPs in making treatment decisions while in their clinical practice [86, 87]. There are, however, a number of problems that prevent HCPs to comply with clinical guidelines: lack of awareness of or familiarity with guidelines, disagreement with guidelines, lack of confidence, and physician not ready to change from established practice and external barriers (e.g. patient related or environmental constraints) to guideline use [88]. It was therefore useful to understand the factors that may influence HCPs use of a PNG within the EM mobile application.

This study aimed to assess the acceptance, use and factors that influence the use of PNG within the EM mobile application among HCPs. Several behavioural theories are useful for understanding and assessing the processes involved in clinician behaviour to promote uptake of mobile health applications as part of their regular practice behaviours [89]. These theories can be useful during the numerous stages of intervention implementation such as; planning, implementing, acceptance and evaluating an intervention such as mobile application [90]. The theory of planned behaviour (TPB) and social cognitive theory (SCT) were reviewed for understanding HCPs' behaviour towards the use of a pesticide specific guideline in a mobile application.

According to the TPB, the most important determinant of a person's behaviour (in this case the regular use of a mobile application) is their intention [91]. This intention is seen to be influenced by three major constructs - that is, the person's attitude, the subjective norm (an individual's opinion about others' anticipations on behaviour whether to execute or not execute) and the perceived behavioural control (which refers to the perceived easiness or an effort of executing the behaviour) [91]. For this research purposes, the study assessed the uptake of the PNG within the EM mobile application, and the attitude

of HCPs towards its use. Furthermore, the study assessed HCP's perceptions in relation to the ease of use of the guideline when making a diagnosis or notification of APPs as an assessment of perceived behavioural control.

Furthermore, the TPB has been shown to be useful in studying the behaviour of HCPs in the application of new skills or information [92-95]. A study by Liabsuetrakul et al. [94] used the TPB to investigate the use of antibiotic prophylaxis among obstetricians in Thailand during caesarean section. It was found that their aim to use a small amount of the antibiotic in these cases were low, and this was due to the negative attitude of the doctors. The negative attitude was centred on the uncertainty regarding the appropriateness of well-resourced trials from other countries (i.e. the developed world) and the repercussions of after caesarean infections. Therefore, constructs such as attitude for example, are useful in assessing the behavioural change of HCPs [96] concerning the use of the PNG within the EM mobile application.

Social cognitive theory (SCT) complements the TBP in analysing HCPs behaviour towards using medical applications by emphasizing the importance not only of intention (e.g. an act of using the pesticide notification guideline to notify APPs) but the impact of other factors, such as environmental. Environmental factors assess the perceived facilitators (advantages) and impediments (disadvantage and challenges) that could influence the behaviour of HCPs when using the PNG within the EM mobile application.

SCT suggests that behaviour change is influenced by personal factors, environmental factors and human behaviour [90]. According to SCT, three primary factors affect behaviour: 1) an individual should have self-efficacy, or confidence in performing the particular behaviour or action; 2), an individual should have a

goal in performing the behaviour or action; and 3) an individual should perceive the advantages in performing the particular behaviour. Additional factors could influence an individual's behaviour [97], which may include knowledge and skills, perceived facilitators and impediments. In SCT, self-efficacy is considered the most important motivation for behavioural change [96, 98]. Therefore, HCPs with high self-efficacy could be more likely to perform the behaviour of diagnosing and notifying APPs (especially from illegal or unlabelled pesticides). Previous studies have reported self-efficacy being correlated with HCPs' adherence to clinical guidelines [99, 100]. An experimental study conducted in the UK found self-efficacy was associated with general practitioners' (GP) intention to adhere to guidelines [99]. The GPs' intended management of upper respiratory tract infection (URTI) was persuaded by their self-confidence in capacity of managing this infection without antibiotics [99]. The description of the above-mentioned theoretical frameworks in the selected studies show certain constructs (e.g. attitude, self-efficacy and advantages/disadvantages) that will be investigated in this research.

4. Gaps in the literature and conclusions

The synthesis of this literature shows that several studies [54, 82, 83] have examined the use of mobile applications to support learning and practice of HCPs in high income countries. There is, however, a scarcity of research addressing the use and evaluated the mobile applications for HCPs in LMICs and this needs to be addressed. This is because HCPs are in need of effective mHealth applications of high quality that could support their clinical practice and training. This could contribute to raising the quality of health care in LMICs. Although HCPs' use of mobile applications has been researched in the context of treating

depression [83], skin cancer [84] and other diseases, less research has been done in relation to managing and notifying APPs. Thus, this study will make an important contribution to the field of mHealth.

It is anticipated that the study findings will provide an improved understanding of utilization of mHealth applications among HCPs in LMICs where notification of APP is important to reduce health risks. In addition, the findings could inform policy to integrate mobile application technology use within health systems, giving HCPs in LIMCs an advanced tools for improving the quality of health care.

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PART C: Journal ‘ready’ manuscript

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Evaluating a South African mobile application for healthcare professionals to improve diagnosis and notification of pesticide poisonings¹

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Abstract

Background: Mobile health (mHealth) is a fast-developing field. The use of mHealth applications by healthcare professionals (HCPs) globally has increased considerably. While several studies in high income countries have investigated HCPs' use of mobile applications in clinical practice, few have been conducted in low-and middle-income countries (LMICs). Specifically, little research has examined the use of applications for identifying and notifying acute pesticide poisonings (APPs). The University of Cape Town (UCT) developed a pesticide notification guideline which has been adapted and embedded into a South African Emergency Medicine Guidance application. This study aimed to evaluate the guideline within a mobile application for improving the ability of HCPs to diagnose and notify APPs.

¹This journal manuscript is written in accordance with requirements as stated in the submission guidelines for authors of the *BMC Public Health* Journal (Appendix D). There were a few changes made from journal submission guidelines in order to comply with the instructions for the mini-thesis. This include: Figures have been inserted in the text of the dissertation instead as separate files as required by the journal. Supplementary materials in this article have been placed in the Appendix E of the mini-dissertation.

Methods: A descriptive online questionnaire, with 15 open and 20 closed-ended questions, was administered to 50 South African emergency medicine physicians and registrars from December 2015 to February 2016. Descriptive statistics were used to calculate response frequencies and percentages. Texts from the open-ended questions were thematically analysed. Fisher's exact test was applied to determine associations.

Results: The majority of participants (73%) knew that APP was a notifiable medical condition, but almost half (49%) had never reported a case to the National Department of Health (DOH) as is required by law. Thirty four percent of the participants were aware of the guideline within the EM Guidance application despite only seven participants having used it. Those who used the guideline found it useful for the identification of unlabelled pesticides products, and believed it created an awareness of notifying APP cases. In addition, it appears to facilitate prompt diagnosis and treatment of APP cases.

Conclusions: In general mobile applications demonstrated to be useful among the participants and most intend to continue using it for training/educational purposes. mHealth applications, therefore, appear to enhance medical education and patient care in LMICs. However, since most participants were not aware of the existence of the pesticide guideline within the studied EM application, health promotion services for applications should be enforced within healthcare systems and medical schools. HCPs need more targeted training through mHealth continuous medical education concerning the importance of notifying APPs.

Keywords: Acute pesticide poisoning, Healthcare professional, Low-and middle-income countries, Mobile health applications, Pesticide notification, South Africa

Background

It is approximated worldwide that three million APP cases happen yearly [1]. APP is a common problem in LMICs and in sub-Saharan Africa context, South Africa (SA) are the biggest user of pesticides [2, 3]. In both occupational and non-occupational settings, pesticide use is extensive and pesticide exposures are common. In SA, APP is a notifiable medical condition, and by law HCPs are required to notify poisonings from any pesticide to the national Department of Health (DOH) [2, 4].

Notification of APP is an important surveillance tool for controlling and reducing the harmful effects from pesticides, particularly from street or illegal pesticides. The importance of this notification system is to alert local or district health services that there is a problem, in order to take appropriate prevention responses. However, this law is not being fully implemented due to reporting problems. For example, only organophosphate-containing pesticides (OPs) are being reported, and not from other pesticide classes such as pyrethroids, carbamates, organochlorines and rat poisons. As a result, many poisoning cases go unreported. This could be related to the limited training of HCP on environmental health related factors and pesticides specifically, as well as on the current practice of only reporting OPs and the lack of awareness that all pesticide classes must be notified.

Studies assessing the adequacy of HCPs training in both high income countries and LMICs on environmental health factors have found that most HCPs have poor training or knowledge for handling these problems such as lead poisoning and APP [5-9]. This is since many medical schools offer little or no training in environmental health [10]. As a result, many HCPs do not conduct an environmental exposure history, which is key when making a diagnosis of APP [9]. In other instances, HCPs may confuse APP symptoms with flu-like symptoms [11] leading to an incorrect diagnosis resulting in poor and ineffective treatment, and poor notification [4]. Another challenge, and one often faced by HCPs in South Africa, is the difficulty of linking APP to illegal or unlabelled street pesticides [12]. Many poor urban residents rely

on cheap, easily accessible toxic pesticides that have been decanted into unlabelled containers for domestic pest control [4]. When an individual is taken for medical care, it becomes difficult for HCPs to diagnose poisonings following exposure to unlabelled products thus, making it difficult to comply with notification requirements. Another challenge is that there is scarcity of easily accessible resources to assist busy HCPs with APP notification [4].

Mobile health (mHealth) presents a unique platform to improve medical education and to assist HCPs in addressing and notifying acute pesticide poisoning (APP) cases, a neglected global public health problem. mHealth, the utilisation of mobile technology in health care, has the potential to support the provision of high quality health care services and keep healthcare professionals (HCPs) up to date, particularly in low- and middle-income countries (LMICs) [13, 14]. In recent years, the use of mobile phones and other mobile devices by HCPs for their clinical practice has been increasing. This has led to the fast development of medical-related mobile applications [15]. These include management and monitoring of patients with different illnesses, clinical decision-making, and medical training and among others [15-21]. Despite this development, there are limited studies that have evaluated the effectiveness of mHealth tools targeted at HCPs [22, 23].

A key aspect in evaluating mHealth is understanding HCP's attitude towards the use of mobile applications. Several studies have examined the use of mobile applications among HCPs and have shown that generally they perceive mobile applications to be essential and effective tools to support their day-to-day work [24-26]. For example, a study conducted in the United Kingdom (UK) evaluated a hospital-specific smartphone application (i.e., iTreat) and found that most doctors felt the application was effective because it saved time during clinical activities reducing the need to refer to cumbersome clinical manuals [25]. In LMICs, and especially in Africa, such perception studies are limited and much needed in order to determine effective mHealth strategies for large-scale use.

To develop South African HCPs capacity to diagnose and notify APPs, the University of Cape Town's Centre for Environmental and Occupational Health Research (CEOHR), together with other stakeholders (academic researchers, NGOs and the SA government), developed a pesticide notification guideline [4]. The guideline is composed of an algorithm, which aims to help HCPs improve notification of APP and a point chart which contains pictures of common street unlabelled pesticides for caregivers or patients to indicate the pesticide product responsible for the poisoning.

The guideline was originally produced as printed material and 20,000 copies were distributed. In 2014, however, this pesticide notification guideline (PNG) was adapted into a South African emergency medicine (EM) mobile application entitled "EM Guidance" (see Fig. 1) [27]. The EM Guidance mHealth application was developed by The Open Medicine Project South Africa (TOMPSA) and designed for use by emergency medicine physicians and registrars. The application was downloaded 9243 and 146 832 times in South Africa and worldwide respectively, between February 2014 – 31 January 2016. The application is freely available for downloading from TOMPSA website (<http://openmedicineproject.org/photo-gallery/emergency-medicine-guidance-app/>) [28], and advertised on a South African EM Facebook page.

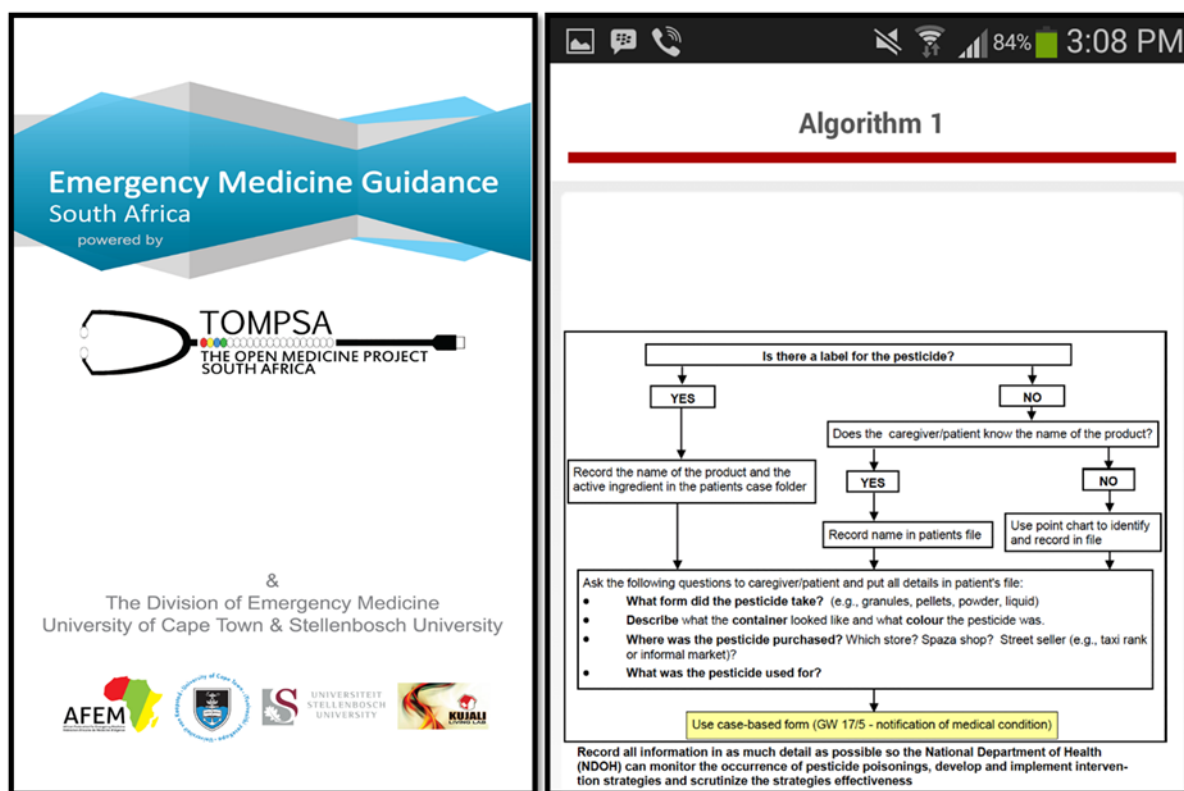


Figure 1: Screen shot of UCT's pesticide notification guideline within the EM Guidance application

This study aimed to evaluate the CEOHR's PNG within the EM mobile application for improving HCPs' ability to diagnose and report APP cases. The research also assessed EM HCPs' understanding of APP as a notifiable medical condition. In addition, the study assessed the use and the impact of the PNG, as well as the ways in which the PNG could be improved to enhance its effectiveness and applicability.

The theory of planned behaviour (TPB) [29] and social cognitive theory (SCT) [30] were used to address the above mentioned aims. The TPB is a well-known theory that has been used to assess healthcare professionals' behaviour [31-33]. According to the TPB, the most important determinant of an individual's behaviour is intention. The intention is influenced by three constructs: attitude, subjective norm (a person's opinion about others' anticipations on behaviour whether to execute or not execute) and

perceived behavioural control (perceived easiness of performing the behaviour) [29]. As for SCT, it helps to understand different factors (i.e. personal, environmental and human behaviour) that influences performing particular behaviour (in this case the use of PNG within the EM Guidance mobile application). In SCT, self-efficacy is regarded as the most important motivation for behavioural change [30]. This was one of the construct that was assessed in this study.

Methods

Study design and sampling

A descriptive survey was conducted with 50 South African emergency medicine registrars and physicians from December 2015 to February 2016. A questionnaire with open and close-ended questions was used to assess the use and the impact of the PNG within the EM mobile application. Participants who agreed to participate in the study were from five of the nine provinces in SA – that is the, Western Cape, Limpopo, Gauteng, Kwazulu-Natal and Northern Cape. Their participation was anonymous and voluntary. A purposive sampling method was used to select emergency medicine registrars and physicians of varying seniority. Eligible participants needed to be emergency medicine registrars and physicians working in SA, because the EM guidance mobile application was designed for these group who are often the first to see a patient with APP. The eligibility criteria also required participants who were willing to partake in the study. Recruitment strategies included sending emails and making phone calls to seventy-three potential participants. Some participants were identified through the SA Medpages Directory website that lists emergency medicine registrars and physicians practicing in SA. Other participants were identified by an emergency medicine physician key informant based in Cape Town. This physician circulated the survey details to emergency medicine physicians and registrars working in Western Cape on behalf of the study

researchers and posted the study request on the SA emergency medicine Vula website and Facebook. Willing participants were emailed the survey link by the first author. Incomplete questionnaires and participants who were not emergency medicine registrars and physicians were excluded from the study.

Survey instrument

The questionnaire was developed based on certain constructs or concepts from TPB (i.e. intention, attitude and perceived behavioural control {advantages/ facilitators or disadvantages/barriers} towards the use of PNG within the EM Guidance mobile application; SCT (i.e. self-efficacy/confidence in reporting APP using the PNG, human behaviour {knowledge and skills}) and relevant literature (i.e. using the PNG within the EM mobile application in the presence of patients or in hospital setting and etc.) [25]. This questionnaire was built into the web-based survey software, SurveyMonkey®, to accommodate HCPs' demanding clinical schedules. An online survey method was used because it is faster to complete and has been shown to have a better return rate with HCPs than paper based surveys [34]. Face-to-face interviews were not possible due to work schedules and location.

The questionnaire was piloted with five non-emergency medicine physicians to ensure the validity and reliability of the questionnaire. The final survey questionnaire (Appendix A) consisted of 20 close and 15 open-ended questions, addressing emergency medicine demographic information, clinical practice in APP, and APP knowledge. It also addressed general use of medical applications, perceived advantages and disadvantages of using the PNG within the EM mobile application and their recommendations for improving it.

A consent page that contained information of the researchers as well as UCT's Health Sciences Human Research Ethics Committee appeared when participants clicked on the survey link. After consent the survey commenced. Responses were automatically collected and collated by the SurveyMonkey®

software. Weekly reminder emails containing the survey link were sent to emergency medicine registrars and physicians to promote survey completion until 58 participants agreed.

Ethics approval was granted from the Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 753/2015) (Appendix C) at the University of Cape Town prior to data collection.

Data analysis

Data were entered into Microsoft Excel (Microsoft Corporation, Redmond, WA) for cleaning and into the Statistical Package for Social Sciences (SPSS) version 23 (SPSS IBM Corporation, Armonk, NY, USA) for analysis. Descriptive statistics were used to calculate response frequencies and percentages. Due to the small sample size and low expected values, a Fisher's exact test was used to determine any specific associations between variables. For meaningful interpretation of the survey responses to the 5-point Likert scale, these were collapsed to three categories: Disagree, neutral (this implies neither disagree nor agree or uncertain), and agree. For all statistical tests, a p-value of < 0.05 was considered statistically significant. Participants provided multiple hospital names when asked which hospital they worked at. In order to simplify the analysis, the data were categorized into hospital level (i.e. public and private hospitals).

Responses to open-ended questions were thematically analysed manually [35]. This involved extensive familiarisation with the data (by reading and re-reading the data and writing down key ideas) and identifying themes or patterns based on relevant literature, the TPB and SCT. Furthermore, subjects/topics raised by participants that recurred in the data were explored. Quotations are included in this journal article to illustrate the common themes and experiences of the participants. In addition, responses to some of the open-ended questions were coded as quantitative data in Microsoft Excel for calculating frequency counts or percentages [36].

Results

Demographic information

A total of 58 of 73 emergency medicine physicians and registrars contacted clicked on the anonymous online survey link. Of these, 50 successfully completed the surveys, six were incomplete, one respondent declined to participate and one respondent did not fulfil the inclusion criteria. The response rate was, therefore, 69% (50 of 73).

The majority of the 50 participants (68%; Table 1) were between 30-39 years old with a male predominance (68%). About 60% of the participants were emergency physicians and 40% were registrars. Nearly half of the participants had been practicing emergency medicine for one to three years, with the majority (82%) working in public hospitals based in the Western Cape (64%).

Table 1: Demographic information of survey participants (N = 50)

	n (%)
Age	
18 - 29	1(2)
30-39	34(68)
40-49	14(28)
50-59	1(2)
Gender	
Female	16(32)
Male	34(68)
Current position	
Emergency medicine registrar	20(40)
Emergency physician	30(60)
Years practicing in current position	
Less than year	7(14)
1-3 years	23(46)
4-6 years	12(24)
More than 6 years	8(16)
Type of hospital currently stationed at	
Public	41(82)
Private	4(8)
Other (i.e. at sea on cruise ships and non-emergency medical services)	5(10)
Province in which the hospital is located	
Gauteng	10(20)
Western Cape	32(64)
Kwazulu-Natal	5(10)
Limpopo	1(2)
Northern Cape	2(4)

Knowledge on pesticide poisonings

To understand participants' history of handling pesticide poisoning cases, they were asked to indicate the number of suspected APP cases they treated and reported in their career. Most participants (92% vs 96%,

respectively) had treated children/adolescents and adults with APPs (Figure 2). Just over half of the participants (56%) had treated more than twenty adult APP cases in their career.

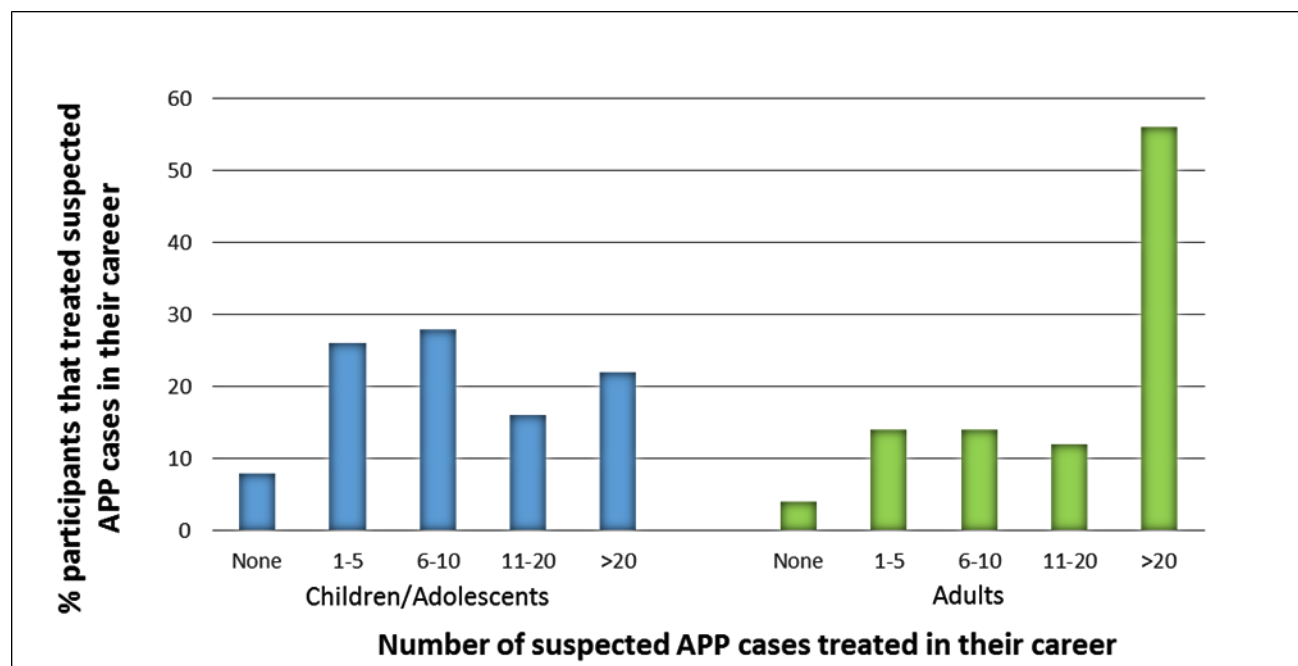


Figure 2: Number of pesticide poisoning cases treated in participants' career

With regard to notification, 72% of participants indicated that APP was a notifiable condition when asked (Table 2) and 68% correctly listing the pesticide classes required to be reported (i.e. carbamates, pyrethroids, organophosphates and anticoagulants). Despite this, results show that less than half of the participants (48%) had never reported any APP cases to the DOH (Figure 3), despite knowing that APP is a notifiable medical condition. This was reflected on the significant association observed between the participants knowing that APP is a notifiable condition with ever reporting the disease to DOH ($p = 0.005$).

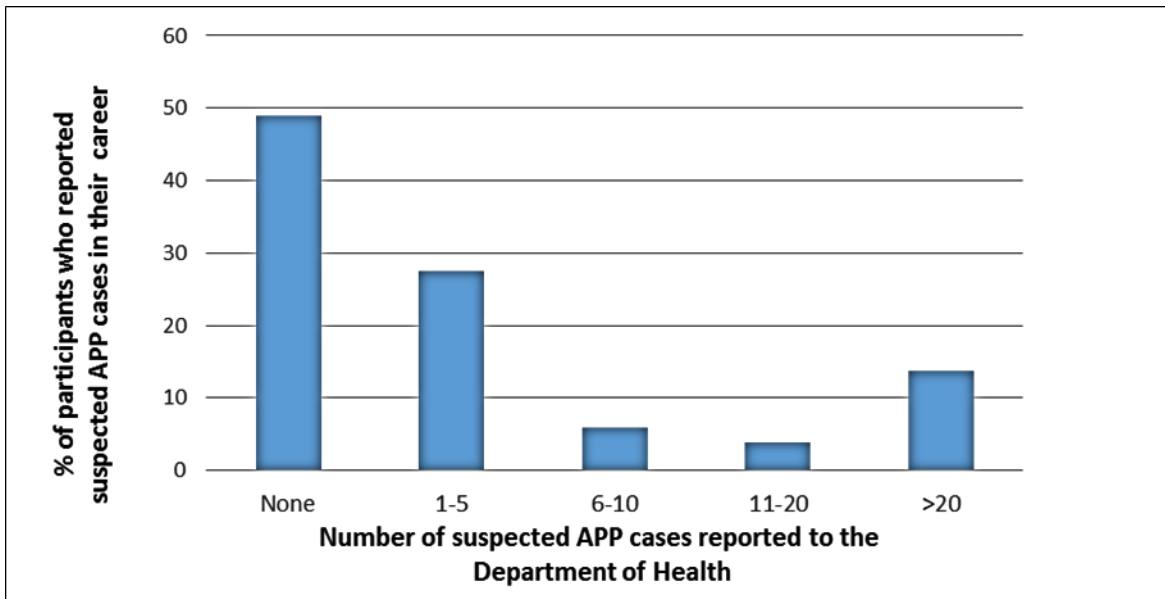


Figure 3: Number of pesticide poisoning cases reported to DOH in their career

Approximately 28% of the participants notified one to five cases of APP, while about 14% notified more than 20 cases since qualifying as a doctor. There appeared to have been confusion in relation to reporting of APP caused by public health pesticide products, for instance 36% of participants were unsure as to whether poisoning caused by mosquito repellents should be notified to the DOH; while 48% indicated reporting was required and 16% disagreed to the statement. Despite 72% indicating that pesticide poisoning is a notifiable medical condition in SA, only 34% were aware reporting procedures of APPs to the DOH, while a further 32% were unsure.

Table 2: Participants' knowledge of pesticide poisonings (N = 50)

	Agree n (%)	Neutral n (%)	Disagree n (%)
Pesticide poisoning is a medical notifiable condition	36 (72)	11 (22)	3 (6)
Poisoning caused by mosquito repellents should be notified to DOH	24 (48)	18 (36)	8 (16)
After diagnosing and treating poisoned patients, I indicate in the case file that the poisoning should be reported to DOH	17 (34)	16 (32)	17 (34)

No significant association was found between pesticide poisoning knowledge and age, gender or job position. However, there was a significant association between years in the position and knowledge of pesticide poisoning in relation to reporting pesticide poisoning cases to the DOH ($p=0.018$). The results showed that 82% of participants who had held their position for at least four to six years were more knowledgeable of reporting poisoning cases to DOH, compared to those with fewer than four years and more than six years' experience (between 25% and 45% respectively).

Participants' mobile application use

Participants were asked to indicate the type of mobile devices they used at work. Most used a smart device, particularly a smartphone-iPhone (65%) (Additional file 1: Figure 1S, Appendix E) with the majority (92%) having medical related applications installed on their devices (Additional file 2: Figure 2S, Appendix E). Of those that had medical related applications, the majority (67%) used their applications daily, while 26% used them weekly (Additional file 3: Figure 3S, Appendix E). The remaining participants used their medical applications occasionally (4.3%) whereas 2.2% rarely used it.

Among participants that used medical related applications (92%), they perceived that these provided them with quick access to clinical guidelines (87%) and useful information at point-of-care (89%) (Table 3). This illustrates the popularity of mobile applications in general among HCPs for clinical practice, with most intending to continue using application for training or educational purposes (87%).

Table 3: Participants' perception regarding use of medical related applications (N = 46)

	Agree n (%)	Neutral n (%)	Disagree n (%)
They provide me with quick access to clinical guidelines	40 (86.9)	2 (4.3)	4 (8.7)
They provide useful information at point-of-care	41 (89.1)	1 (2.2)	4 (8.7)
I will continue to use for training/educational purposes	40 (86.9)	1 (2.2)	5 (10.9)

Less than a third of participants (22%) did not cite any medical related applications, while 8% did not have any medical applications in their mobile phones. The EM Guidance was among the most commonly owned medical application (40%), with the majority (80%) aware of the South African EM Guidance application.

Awareness of the pesticide notification guideline

Despite 33% (n=13) of the respondents indicating awareness of the PNG within the EM mobile application, only seven confirmed having used it. There was no association found between those who treated APP cases (among adults, $p = 0.462$ and children, $p = 0.476$) and those who used the PNG within the EM mobile application. However, five of the seven participants who used the PNG within the EM mobile application treated more than 20 APP cases; while the remaining two participants had treated 11 to 20 APP cases. Six participants found the guideline to be useful, user friendly, and easy to use in the presence of the patient and indicated a desire to continue using it in the future. It was important to note that the seven participants that used the PNG within the EM mobile application found it suitably designed for use in a medical setting as it was quickly accessible.

The remaining six of 13 participants aware of PNG within the EM mobile application had not used the guideline because they had not recently encountered APP cases, or only recently downloaded the EM Guidance application but never used the guideline in medical practice. One of the six participants commented that the pesticide guideline was not user-friendly without providing a reason.

Pesticide notification guideline

Use of guideline

Although awareness of the PNG was low amongst the participants, understanding the seven participants' perspectives and how they used the guideline for APP notification is important as this information will help in improving the PNG in the future. Four of the seven participants agreed that the PNG aided them with the process of notifying pesticide poisoning cases, and three agreed that the guideline assisted in improving the number of APP being reported (Table 4). Four of the seven participants found the pesticide guideline improved their confidence in reporting APP cases, particularly their ability to report poisonings from street or unlabelled pesticides. Comments illustrating this included:

"I confirmed a pesticide as being a Paraquat - and as a result this altered patient disposition dramatically and resulted in a case being reported to DOH and farm owner investigated...the guideline has also improved my knowledge on how to report and I also found point chart to be very useful." [R1]

"It has alerted one to the concept of notification and advised on the appropriate form to be completed." [R3]

“Possible improvement in my skills due to easier identification of packaging.” [R6]

Table 4: Participants’ attitudes on the pesticide notification guideline for notifying APP (N=7)

	Agree n (%)	Neutral n (%)	Disagree n (%)
It has aided me with the process for notifying pesticide poisoning cases	4 (57.2)	2 (28.6)	1 (14.3)
It has assisted in improving on the number of pesticide poisoning cases I have reported	3 (42.9)	2 (28.6)	2 (28.6)
It has improved my confidence to report pesticide poisoning cases	4 (57.2)	0	3 (42.9)
It has improved my ability to report poisonings from street or unlabelled pesticides	4 (57.2)	1 (14.3)	2 (28.6)

Although the PNG within the EM Guidance application is meant to promote better notification of APP, it has the potential to also promote better and more accurate diagnosis. However, only three of the seven participants used the guideline for diagnosing. One participant commented that:

“The point chart was shown to patient’s family to help guide us to determine which pesticide patient had ingested.” [R1]

Five of the seven participants perceived the pesticide notification guideline to have assisted them in identifying unlabelled pesticide products such as carbamates using the point chart. For example, one participant mentioned that in some instances, patients bring containers to the hospital. The use of the guideline was an easy reference to identify unlabelled pesticide products.

Emergency medicine physicians and registrars also mentioned barriers or disadvantages related to the use of the pesticide notification guideline. Some participants felt that the pesticide notification guideline lacked contact information.

“Not enough information on application. Contacted poison information centre if known active ingredient/ name of pesticide.” [R7]

For others, the concern was with network in downloading the images of the application:

“If there is poor network, it slow to load images.” [R5]

“Potential disadvantage is poor 3G signal.” [R6]

Features of the pesticide notification guideline

Six of the seven participants indicated that the text format displayed on the pesticide guideline was least useful (Figure 4). An algorithm that is in the PNG is intended to assist HCPs improve notification of APPs. The algorithm was found to be moderately useful because of the simplicity of the message, such as outlining the decision-making process to be followed when presented with APP case, especially when the pesticide is unlabelled.

Images were shown to be most useful among four of the seven participants. However, other participants indicated that they did not use images, since there were not enough pictures to support them in clinical diagnosis. While other participants indicated that they could not use the images, since patients would be unconscious or in unstable condition to assist the doctor to identify unlabelled pesticide product responsible for the poisoning.

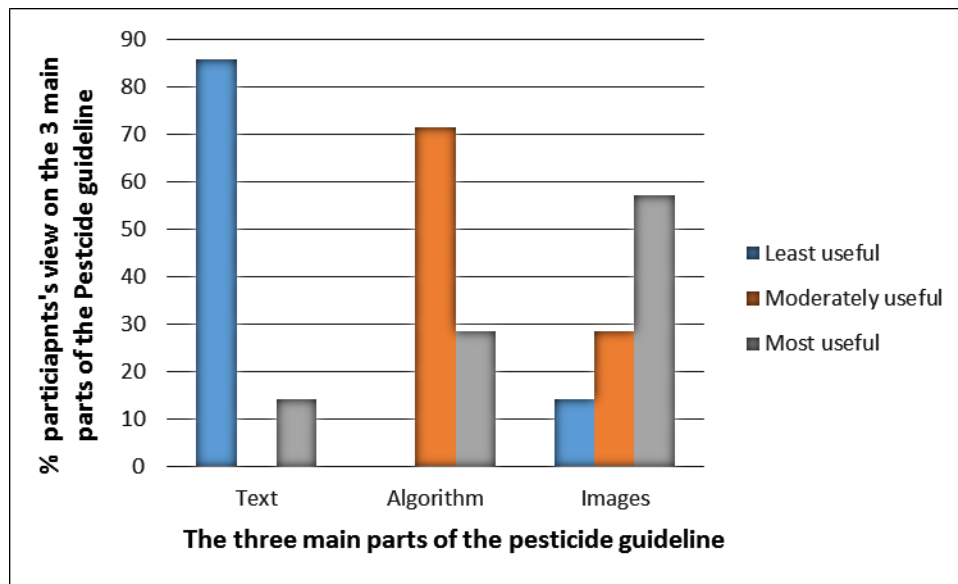


Figure 4: Participants' perceptions of pesticide guideline components (N = 7)

Recommendations to improve the PNG within the EM mobile application

Twenty percent of the participants who were not aware of the EM Guidance mobile application and, 68% of the participants who did not know that the PNG is within the application or had not used it, indicated that they would consider obtaining and using the pesticide guideline in the future. When questioned what information they would find useful for the PNG to contain, 74% of the participants provided recommendations listed in Table 5. Most participants suggested that the guideline should contain clinical related information, such as antidotes with dosages that may assist HCPs to manage a poisoning. This information was seen as useful when accessible on an application in a busy ward. Other participants appreciated the idea of having clinical toxidromes to help them to recognize signs and symptoms of APP. Some of the study participants commented on the need for a link to the notification form to automatically notify APPs through the mobile application. The suggestion was that this approach could encourage HCPs to notify more APPs.

Table 5: Recommendations for improving the PNG within the EM mobile application (N= 32)

Participants	Recommendations	n
	The PNG within the EM mobile application should contain antidotes with dosages for poisoning situations (e.g. atropine infusion for organophosphate poisoning).	11
	The PNG within the EM mobile application should contain algorithms for treatment of poison exposures and lists of signs and symptoms/clinical toxidromes related to poisonings.	9
	The PNG within the EM mobile application should contain an inbuilt link where HCPs could click to notify a case to DOH without having to redo it on paper (Fill in details on application which emails notification).	5
	The PNG within the EM mobile application should contain data that send HCPs reminders on how to use it and or regular updates on the guideline.	2
	Contact numbers should be provided in the PNG within the EM mobile application to assist HCPs when enquiring for advice when managing common poisonings (Poison Control Centre telephone link).	2
	The PNG within the EM mobile application should contain more images. Other suggestions have already been commented by those who did not use the pesticide notification guideline.	3

The participants that had used the PNG had similar suggestions (such as a link to notify cases and clinical toxidromes) to those provided by non-guideline users. However, they mostly emphasised a need for additional images. One respondent commented:

“Need a LOT more photos. Clinical treatment and signs and symptoms and investigations need to be included.” [R1]

Discussion

The study population of this study was a small emergency medicine specialists and trainees in SA because the EM Guidance application being reviewed was for this group. This group of HCPs are specialised and limited in SA as reported in another study [37]. Nevertheless, the findings of our study showed that most

of the participants were aware that APP is a notifiable medical condition. They could list different classes of pesticides that should be notified to the DOH. Despite this, most of the participants do not notify APPs. Previous studies in other LMICs have identified possible reasons for HCPs not reporting notifiable diseases [4, 38, 39]. These reasons included busy HCPs having limited time, poor awareness about the prerequisite reporting forms and lack of printed forms. However, a possible reason in our study is that there is poor recognition among HCPs on the value of notifying APPs to DOH and it is a time-consuming exercise.

Our findings showed a significant association between the number of years of work experience of emergency medicine physicians and registrars and knowledge of reporting APP to the DOH. That is, those who were in their position for at least four to six years were more knowledgeable on reporting APPs to the DOH, in comparison to those with less than four years' experience. This suggests that experienced emergency medicine physicians and registrars are more likely to report APP; it could be assumed that the more experience the participant had on the job with APP the more knowledgeable they became. However, this could not be explained as to why emergency medicine physicians and registrars with more than six years in practice were less knowledgeable on reporting APPs to the DOH. Perhaps it was a result of notification fatigue. It is also possible that this finding was due to chance or coincidence and therefore, it will be useful for future studies to assess the association with a large sample size. Nevertheless, it will be interesting for future studies to examine why HCPs are still not reporting APP cases, despite being aware that it is a notifiable medical condition. This is concerning, especially since HCPs are required by law to report any suspected APP cases to the DOH [2, 4]. Thus, the results suggest an urgent need for educational interventions among HCPs to create awareness and improve notification of APPs.

With most participants owning smartphones, mobile applications could become useful tools in assisting HCPs daily in their workday practice as observed in our finding. This finding is consistent with previous studies conducted in the United States (US) and the UK [25, 40]. The EM Guidance application was one of the most commonly owned medical-related application amongst participants. It is important to note that

having a mobile application on the phone is not an indication of using it. There was low awareness of the existence of the PNG within the EM Guidance mobile application. Awareness is regarded as the first step that would increase the likelihood of an individual to use a specific guideline [41]. Cabana et al. [42] mentioned that lack of awareness is one of the factors that contributes to the non-implementation of guidelines among HCPs. This could explain one of the reasons why so few participants had used the pesticide notification guideline. Since the EM Guidance application was developed in April 2014, there is a possibility that many participants may not yet have discovered the guideline. This highlights the need to more proactively advertise the PNG and its relevance. Amongst the participants aware of the guideline, some had never used it as they had only recently downloaded the EM Guidance mobile application. A similar finding related to the period for the dissemination of a guideline was observed in the US, where only 34% of physicians were aware of the existence of the guideline on depression, one year after its publication [43]. Given that APP is a major public health problem, efforts are needed to create a widespread awareness of the PNG amongst HCPs through conferences, continuous medical education publications, programmes or seminars. It could also be useful if APP reporting is repeatedly taught during medical undergraduate studies. This could ensure that doctors are aware of the importance of notifying APP to the DOH. This might also assist the HCPs to improve on the notification process, which will enable DOH to put measures in place to reduce APPs. Such approaches would not only draw attention to the mobile application but also encourage HCPs to diagnose and notify pesticide poisoning cases more consistently.

The TPB provides a useful framework to understand participants' use or lack use of the PNG within EM Guidance mobile application. According to the TPB, intention to use a guideline is influenced by three major constructs: attitude of the HCP, the subjective norm (i.e. perceptions of the views of other HCPs on the adoption of the pesticide notification guideline) and the perceived behavioural control (i.e. HCP's perception on how difficult or easy in using the PNG to diagnose and notify APPs) [29]. Attitude has been

considered an important predictor of HCPs' intention to follow the recommendations within a guideline [29]. For example, a study by Limbert and Lamb [44] found attitude as the main prognosticator of intention to utilize the antibiotic guideline. The authors found that doctors had positive attitudes towards the antibiotic clinical guideline because it was useful, and they intended to continue using it. This finding was similarly observed in our study, where six participants of the seven participants had good attitude towards the pesticide notification guideline, indicating that the participants intend to continue using it.

The SCT provided insight into the HCPs' behaviour change in the use of PNG during clinical practice. Self-efficacy is the key construct of the SCT for behavioural change [30]. Self-efficacy emphasises on how confident an individual is in performing a particular behaviour. In a UK study, Hrisos et al. [45] found that self-efficacy was linked to general practitioners' (GP) intention to adhere to guidelines. That is, a GP's confidence in managing upper respiratory tract infection (URTI). This is consistent with our study. Four of the seven participants indicated that use of the PNG improved their confidence in reporting APP cases, particularly those of street or unlabelled pesticides. This suggests it is likely that the participants will adhere to the guideline, to ensure reporting of APPs. However, three participants felt that the use of the guideline did not improve their confidence, with reasons that are unknown. It is possible that these participants were familiar with the notification system process, and therefore found no significant change in their confidence in management and notification of APPs. Future studies should investigate this.

The seven participants that used the PNG were comfortable with using the guideline within their mobile device during patient consultations or within the medical setting. In this study, "comfortable" referred to accessing the PNG within the mobile device application in front of patients or in the hospital/clinical setting. Discomfort, therefore, was not related to the use of the mobile device and, was not a factor in this study. This finding is in contrast with the UK study where participants felt it was unprofessional to use mobile devices during patient consultations or within the hospital setting [25]. The disparity in these results are likely due to the cultural concerns related with using a mobile medical application in the

hospital, which could differ worldwide. It should be noted that the UK study findings are drawn from one hospital, and may not be generalizable to other hospitals settings.

One of the reported disadvantages/barriers regarding the use of the PNG within the EM mobile application was that poor mobile phone reception/signal makes loading of images difficult. This can affect HCPs when they are in the process of showing patients the images to identify which pesticides they had been exposed to. The issue of mobile applications concerning slow download speed has also been described in other studies [46]. Such an issue may be resolved by ensuring that hospitals have effective Wi-Fi and sufficient coverage to support mobile application use.

The PNG is the first attempt to support notification and diagnosis of APP. As participants highlighted, however, there is room for improvement. One of the recommendations given by the PNG users was the need for more images/photos of street and commercial pesticides requiring more use of bandwidth. This indicates that images are more appealing and useful to HCPs, especially when faced with an APP case from unlabelled pesticide product. Since mHealth applications are becoming common tools for accessing clinical materials [15], integrating more photos and clinical toxidrome information (i.e. the signs and symptoms that are frequently met with certain drug classes including cholinergic for organophosphates cases) in the PNG could assist HCPs to promptly diagnose and treat poisoned patients. Another recommendation suggested was having clinical toxidrome in the PNG within the EM mobile application. Since most HCPs encounter problems of misdiagnosis of APPs, application developers could consider including a diagnosis section within the PNG to assist HCPs in identifying the signs and symptoms of APPs.

HCPs usually have busy schedules within a hectic hospital environment (such as an emergency department), as a result they may not find time to put on record for APP cases to be notified to the health department. In such a situation, mobile applications are regarded as convenient tools in clinical practice to accomplish several tasks and provide HCPs with increased efficiencies [15]. Therefore, having a link in

the PNG within the EM mobile application that HCPs may use to notify APPs is desirable, as recommended by study participants. Such recommendations are important to consider to increase the effectiveness of the guideline to improve health-care service delivery.

Study limitations

There were a few limitations in this study. Firstly, because of the small sample size, it limits the generalizability and statistical significance of these study findings. Secondly, there was a low uptake of the PNG among participants which impacted the findings. Furthermore, the EM Guidance application was assessed early after its development and accessed only in the mobile application for emergency medicine health professionals. Therefore, it may be useful to include the PNG in other medical applications besides the EM mobile application. Thirdly, there was a predominance of research respondents from Western Cape when compared with other provinces. This could possibly be attributed to the fact that the EM profession is well-established in the Western Cape and therefore more of these professionals are found in this region. In addition, recruitment strategies (i.e. involvement of the EM physician based in Western Cape in the recruitment and research process) could have elicited good response/participation rates in Western Cape in comparison to other provinces, where only emails and phone calls were used. Finally, individuals who were not familiar with or had not used the pesticide guideline were included in the study and therefore they could not answer some of the questions regarding the guideline. Despite these limitations, this study has contributed in the area where there is limited literature. That is, this study gave insight on the use of mobile applications among HCPs in SA, as very few studies have assessed this phenomenon in LMICs, particularly in Africa.

Future studies using a qualitative methodology (e.g. in-depth interviews) are required to investigate the use of the pesticide identification guideline among HCPs. A qualitative approach could help to answer the “why” (e.g. why HCPs are not notifying APPs cases) and “how” (e.g. how the guideline could be improved)

questions and also generate detailed information into the perceptions and experiences of HCPs who have used the pesticide guideline.

Conclusion

To our knowledge, this is the first research that has examined the acceptance, use and factors that influence the use the PNG within the EM mobile application to support HCPs in diagnosis and notification of APPs. The high use of mobile ownership among emergency medicine registrars and physicians demonstrates that the mHealth platform could be promising in LMICs (i.e. South Africa) to provide support and continued learning to HCPs. In addition, integrating the mHealth interventions (i.e. EM Guidance mobile application) within the health system could enhance HCPs to notify APPs. This is due to the convenience and efficacy of mobile technology in comparison to the traditional paper-based methods. Hence mobile application developers need to turn their attention to producing high quality medical mobile applications to fill HCPs knowledge gaps. Lastly, health promotion services for mobile applications should be enforced within healthcare systems and medical schools to encourage awareness of the new clinical guidelines (i.e. pesticide notification guideline) among HCPs.

List of abbreviations

APP, (Acute pesticide poisoning); CEOHR, (Centre for Environmental and Occupational Health Research); DOH, (Department of Health); EM, (Emergency medicine); GPs, (General Practitioners); HCPs (Healthcare professional); LMICs,(Low-and middle-income countries); mHealth, (Mobile Health); OPs, (Organophosphates); SA, (South Africa); SCT, (Social Cognitive Theory); SPSS, (Statistical Package for Social Sciences); TPB, (Theory of planned behaviour); UCT, (University of Cape Town); UK, (United Kingdom); URTI, (Upper Respiratory Tract Infection); US, (United States).

Declarations

Competing interests

The researcher declares that there was no conflict of interests in this study.

Ethics approval and consent to participate

Ethics approval was granted from the Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 753/2015) at the University of Cape Town. Participants gave informed consent before they filled an online survey for the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

SK developed the protocol, collected and analysed the data and wrote the article. H-AR was the principal investigator of the study, conceptualised and supervised the study. All authors read and approved the final manuscript.

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PART D: APPENDICES

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Appendix A: Questionnaire

SECTION A – DEMOGRAPHIC INFORMATION

1. Age:

☐ 18-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐ 69+

2. Gender:

☐ Female ☐ Male

3. What is your current position?

☐ Emergency medicine registrar ☐ Emergency physician

4. For how long have you been in this position?

☐ Less than year ☐ 1-3 years ☐ 4 – 6 years ☐ More than 6 years

5. Which hospital are you currently stationed at?

6. Which province is your hospital stationed?

☐ Gauteng ☐ Western Cape ☐ Kwazulu-Natal ☐ Limpopo ☐ Other (please specify)

7. Approximately what number of suspected pesticide poisoning cases have you treated and reported in your career?

	None	1-5	6 – 10	11 – 20	>20
Children/adolescents treated in your career (1day -18yrs)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Adults treated in your career	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cases ever reported to Department of Health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

SECTION B: KNOWLDEGE ON PESTICIDE POISONINGS

8. Please tick to which extent you agree with the statements below. Choose only one per row

	Strongly agree	Agree	neutral	Disagree	Strongly disagree
Pesticide poisoning is a medical notifiable condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment: If pesticide poisoning is a notifiable condition, please list the pesticide chemical class or classes which need to be notified (e.g., organophosphates, pyrethroids, carbamates, herbicides)

Poisoning caused by mosquito repellents should be notified to Department of Health	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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After diagnosing and treating ☐ ☐ ☐ ☐ ☐

poisoned patients, I indicate in the
case file that the poisoning should
be reported to Department of Health

SECTION C – MOBILE APPLICATION AND PESTICIDE DIAGNOSIS AND NOTIFICATION

GUIDELINE USE

9. Which mobile device/s do you use while at work? (Tick all relevant)?

☐ Tablet – Android ☐ Tablet – iPad ☐ Smartphone - Android

☐ Smartphone – iPhone ☐ Other (please specify) ☐ None

10. Do you have medical related applications on your current mobile devices that you use at work?

☐ Yes ☐ No

11. If yes, please list which ones:

12. How often do you use the medical related applications?

☐ Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐ Rarely

13. These following statements are related to your use of medical related applications

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
They provide me with quick access to clinical guidelines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

They provide useful information ☐ ☐ ☐ ☐ ☐
at point-of-care

I will continue to use the medical ☐ ☐ ☐ ☐ ☐
related applications for training/educational
purposes

14. Are you are aware of the Western Cape medical application entitled Emergency Medicine (EM)

Guidance created by TOMPSA (The Open Medicine Project South Africa)?

☐ Yes ☐ No

If no, skip to Section G

15. If yes, have you used this application?

☐ Yes ☐ No

16. If no, why have you not used this application?

17. Are you aware that there is a tool inside the Toxicology Section of this application to aide with

Pesticide Diagnosis and Notification?

☐ Yes ☐ No

If no, skip to Section G

18. If yes, have you used the tool?

☐ Yes ☐ No

If yes, then please answer questions, 20-32

19. If no, why have you not used the tool? And also answer only Section G

20. The following statements are related to what you think about the pesticide guideline section of the EM Guidance

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
It is useful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It is user friendly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It is easy of use in the presence of patient	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I intend to continue using the pesticide guideline section of the EM Guidance application	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

21. The following statements are related to what you think about the pesticide guideline section of the EM Guidance for supporting the notification of pesticide poisoning cases

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
It has aided me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
with the process for notifying					
pesticide poisoning cases					
It has assisted in improving	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
on the number of pesticide					
poisoning cases I have reported					
It has improved my confidence level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
to report pesticide poisoning					
cases					
It has improved my ability to report	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
poisonings from street or unlabelled					
pesticides					

22. Although the pesticide guideline section of EM Guidance application is meant to promote better notification of pesticide poisoning, it could be useful for diagnosis. Have you used the application for diagnosis purposes?

☐ Yes ☐ No

23. If yes, please give an example of how the information was used.

24. Please provide an example of how the use of pesticide diagnosis and notification section of the EM Guidance application aided you in diagnosing and notification of pesticide poisoning cases from both commercially bought pesticides and unlabelled street pesticides? Please explain

25. How has the use of pesticide diagnosis and notification section of the EM Guidance application contribute in improved diagnosis and notification of pesticide poisoning cases (especially poisonings from street or unlabelled pesticides)? Please explain how or why not?

SECTION D- EVALUATING THE PESTICIDE DIAGNOSIS AND NOTIFICATION SECTION OF THE EM GUIDANCE APPLICATION FEATURES

The Pesticide diagnosis and notification section has 3 main parts:

- (a) Text (Consists of all pesticide active ingredients info)
- (b) Algorithm (Process to identify and report pesticides)
- (c) Images (Showing pesticides involved)

26. On a scale of 1-3, please rank the following parts of the pesticide diagnosis and notification section of the EM Guidance application (with the 3 being the most useful and 1 being the least useful)

- ☐ Text
- ☐ Algorithm
- ☐ Images

Comment:

27. When consulting with your patients do you use the images present in the pesticide diagnosis and notification section of the EM guidance application? If no why? And if yes, how has it aided you/how useful is this part?
28. Can you please list the advantages/some of successes you had in using the pesticide diagnosis and notification section of the EM Guidance application? Please give examples
29. Can you please list the disadvantages/drawbacks you encountered in using the pesticide diagnosis and notification section of the EM Guidance application? And how did you overcome them?
30. Is pesticide diagnosis and notification section of the EM Guidance application suitable designed to use while you are at your workplace environment? Please explain

SECTION E – IMPROVED KNOWLEDGE AND SKILLS THROUGH THE USE OF PESTICIDE

DIAGNOSIS AND NOTIFICATION SECTION OF THE EM GUIDANCE APPLICATION

31. How has using the pesticide diagnosis and notification section of the EM Guidance application improved your knowledge and skills on better diagnosis and reporting of pesticide poisoning cases? Please explain

SECTION F– RECOMMENDATIONS FOR IMPROVEMENT

32. What improvements would you suggest for the pesticide diagnosis and notification section of the EM Guidance mobile application? (i.e. are the photos sufficient (or do you need additional images for pesticides not included?) Particularly taking your needs into account.

SECTION G- IF YOU HAVE NOT HEARD/USED EM GUIDANCE APPLICATION OR PESTICIDE

DIAGNOSIS AND NOTIFICATION SECTION

Emergency Medicine Guidance application is a clinical reference guideline for health care professionals that contains information such as trauma, orthopaedics and toxicology (in which information on pesticide diagnosis and notification is found). The pesticide notification guideline provides a summary for the procedure that should be followed when healthcare professionals are presented with poisoning cases, particularly when an unlabelled pesticide is involved. The link to the application can be found at this website: <https://play.google.com/store/apps/details?id=emguidance.tompsa&hl=en>.

33. Would you consider obtaining the application and using the pesticide diagnosis and notification section?

☐ Yes ☐ No

34. If no, why?

35. What information would you find useful for an application to contain to improve your diagnosis, treatment and reporting of pesticide poisoning cases?

Thank you very much for participating in this study. Your time and effort is greatly appreciated.

REMINDER: Pesticide Poisoning a Notifiable Condition

In South Africa, pesticide poisoning is a notifiable medical condition. It is the duty of healthcare professionals to report any suspected pesticide poisoning to the Department of Health. Please see the following link that explains the notification process:

http://www.scielo.org.za/scielo.php?pid=S0256-95742012000600057&script=sci_arttext.

The notification of pesticide poisonings assist in monitoring and control of pesticides, particularly street pesticides. Furthermore, identifying targets for public health intervention and prevention practices.

http://www.epa.gov/sites/production/files/2015-01/documents/rmpp_6thed_final_lowresopt.pdf

Appendix B: Consent form

My name is Siti Kabanda and I am a Masters of Public health student at the University of Cape Town. I would like to invite you to participate in a research study for my mini-dissertation and would like to ask for your permission to be part of this study. The study aims to evaluate the acceptance, use and factors that influence the use of the pesticide notification guideline available within the TOMPSA Emergency Medicine Guidance mobile application for healthcare professionals in improving diagnosis and notification of pesticide poisonings.

Your participation in this study is very important and will help us understand how useful the application has been among healthcare professionals and how it can be enhanced. There are no risks recognized in participating in this study. There will not be individual benefits of participating in the study. However, the researcher will be giving information to the participants that may be of benefit to their future practice.

Any information that you provide is confidential. For example, your name will not appear on any of the questionnaires and there will be no means to identify your specific answers. The data will be kept in the researcher's personal computer that has a protected password and will be destroyed after the study. Please understand that your participation is voluntary. You may decline to participate or you can withdraw from participation any time you wish with no consequences. However, I would be grateful if you would assist to answer the full questionnaire. If you choose to participate, you will be asked to answer approximately thirty five questions, which will take about 10 minutes to 15 minutes.

Should you have any questions regarding the research study please feel free to contact me on 0722491467 or email me at siti.m.kabanda@gmail.com or contact the following:

Study Principal Investigator

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Chairperson of Human Research Ethic Committee

Professor M Blockman

UCT, Health Sciences Faculty

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I have read the information above, understand that I can withdraw at any time and confirm that I am willing to take part in this study.

☐ Yes (This will start the survey) ☐ No (This will exit the survey)

Appendix C: Official letter of ethical approval from University of Cape Town Faculty of Health Science Research Ethics Committee



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room E52-24 Old Main Building
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Email: sunayali.ariel@uct.ac.za

Website: www.health.uct.ac.za/fhs/research/humanethics/forms

20 November 2015

HREC REF: 753/2015

A/Prof A Rother
Environmental Health Division
Public Health & Family Medicine
Room 4.28, Level 4
Falmouth Building

Dear Prof Rother

**PROJECT TITLE: EVALUATING THE EFFECTIVENESS OF A MOBILE APPLICATION FOR
HEALTHCARE PROFESSIONALS TO IMPROVE DIAGNOSIS AND NOTIFICATION OF PESTICIDE
POISONINGS (Masters candidate – Ma S Kabanda)**

Thank you for your response letter dated 17 November 2015, addressing the issues raised by the Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th November 2016.

Please add a name to the contact information on the Informed Consent document and not the GHS switchboard.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the following student:- Siti Kabanda is also involved in this project.

Please quote the HREC reference no in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Hrec/ref:753/2015

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix D: Instructions for authors: The BMC Public Health Journal

Source: <http://old.biomedcentral.com/bmchealthservres/authors/instructions/researcharticle>

Research articles

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Manuscripts for Research articles submitted to *BMC Health Services Research* should be divided into the following sections (in this order):

[Title page](#)

[Abstract](#)

[Keywords](#)

[Background](#)

[Methods](#)

[Results and discussion](#)

[Conclusions](#)

[List of abbreviations used](#) (if any)

[Competing interests](#)

[Authors' contributions](#)

[Authors' information](#)

[Acknowledgements](#)

[Endnotes](#)

[References](#)

[Illustrations and figures](#) (if any)

[Tables and captions](#)

[Preparing additional files](#)

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Article within a journal by DOI

Slifka MK, Whitton JL. Clinical implications of dysregulated cytokine production. *Dig J Mol Med*. 2000; doi:10.1007/s801090000086.

Article within a journal supplement

Frumin AM, Nussbaum J, Esposito M. Functional asplenia: demonstration of splenic activity by bone marrow scan. *Blood* 1979;59 Suppl 1:26-32.

Book chapter, or an article within a book

Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. *International review of cytology*. London: Academic; 1980. p. 251-306.

OnlineFirst chapter in a series (without a volume designation but with a DOI)

Saito Y, Hyuga H. Rate equation approaches to amplification of enantiomeric excess and chiral symmetry breaking. *Top Curr Chem*. 2007. doi:10.1007/128_2006_108.

Complete book, authored

Blenkinsopp A, Paxton P. *Symptoms in the pharmacy: a guide to the management of common illness*. 3rd ed. Oxford: Blackwell Science; 1998.

Online document

Doe J. Title of subordinate document. In: *The dictionary of substances and their effects*. Royal Society of Chemistry. 1999. <http://www.rsc.org/dose/title of subordinate document>. Accessed 15 Jan 1999.

Online database

Healthwise Knowledgebase. *US Pharmacopeia*, Rockville. 1998. <http://www.healthwise.org>. Accessed 21 Sept 1998.

Supplementary material/private homepage

Doe J. Title of supplementary material. 2000. <http://www.privatehomepage.com>. Accessed 22 Feb 2000.

University site

Doe, J: Title of preprint. <http://www.uni-heidelberg.de/mydata.html> (1999). Accessed 25 Dec 1999.

FTP site

Doe, J: Trivial HTTP, RFC2169. <ftp://ftp.isi.edu/in-notes/rfc2169.txt> (1999). Accessed 12 Nov 1999.

Organization site

ISSN International Centre: The ISSN register. <http://www.issn.org> (2006). Accessed 20 Feb 2007.

Dataset with persistent identifier

Zheng L-Y, Guo X-S, He B, Sun L-J, Peng Y, Dong S-S, et al. Genome data from sweet and grain sorghum (*Sorghum bicolor*). GigaScience Database. 2011. <http://dx.doi.org/10.5524/100012>.

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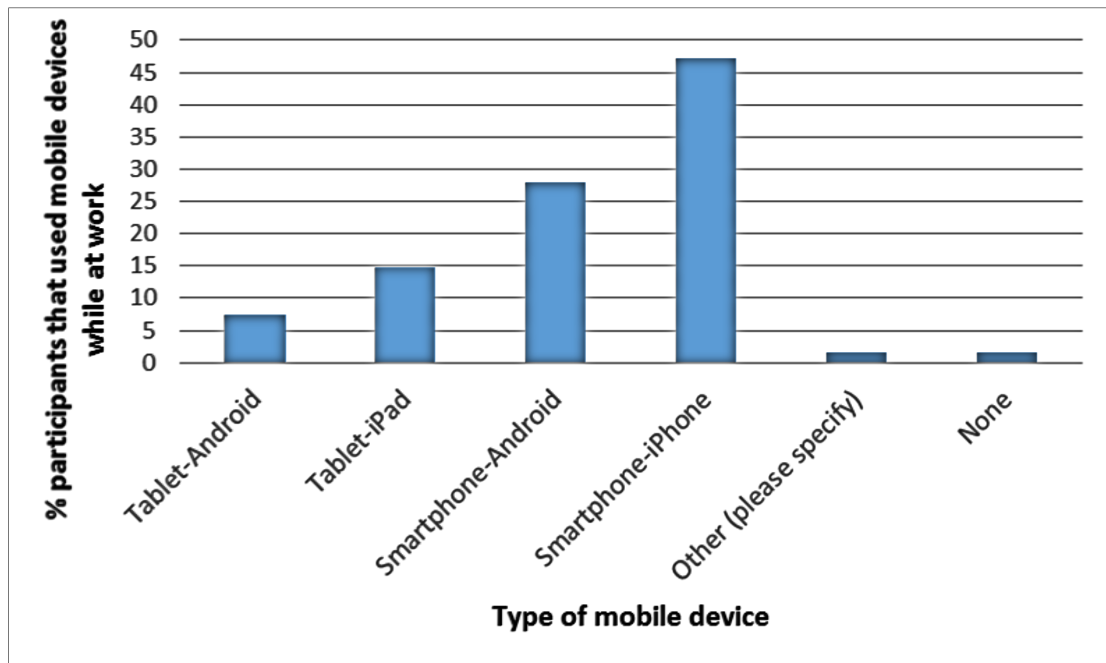
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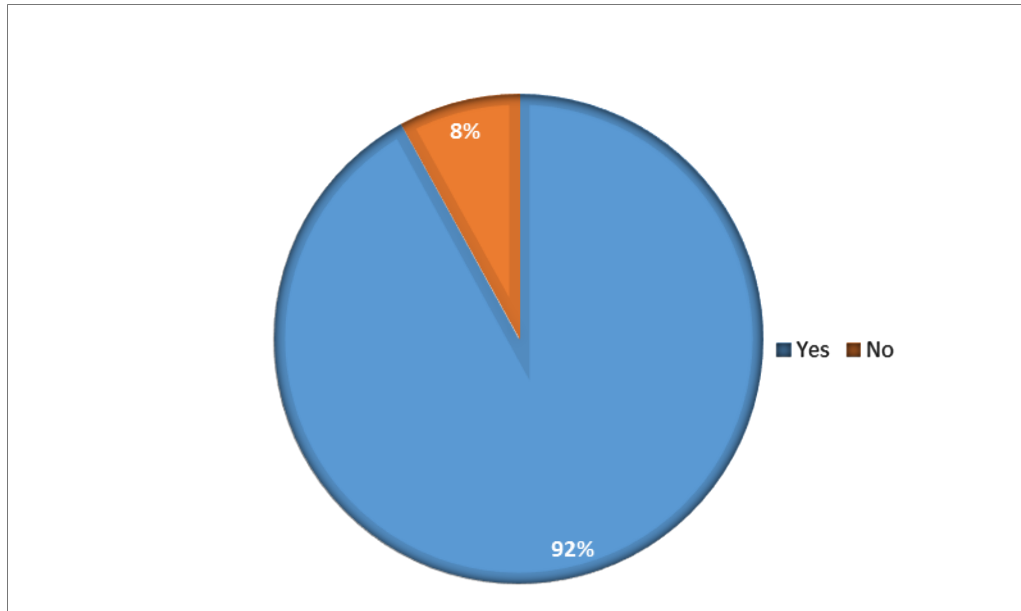
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Appendix E: Supplementary tables and figures for ‘journal ready manuscript’

Supplementary Figure 1: Illustration of the type of mobile devices owned and used by participants at their work place



Supplementary Figure 2: Illustrates the number of participants that have medical related applications in their mobile devices



Supplementary Figure 3: Illustrates the frequency use among those that own medical related applications

